INTERNATIONAL SCIENCE FICTION

PROTOTYPING CONFERENCE

2019

SciFi-It'2019

DESIGNING YOUR FUTURE
WITH
SCIENCE FICTION

EDITED BY

Philippe Geril

APRIL 1-3, 2019

DE KROOK, GHENT

BELGIUM

A Publication of EUROSIS-ETI

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The 3rd Annual Science Fiction Prototyping Conference 2019

GHENT, BELGIUM

APRIL 1-3, 2019

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EUROSIS-ETI Proceedings are referenced and indexed on ISI Web of Knowledge, IET, SCOPUS and Elsevier Engineering Village.

A CIP Catalogue record for this book is available from the Royal Library of Belgium under nr.12620

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EUROSIS is a Division of ETI Bvba, The European Technology Institute, Torhoutsesteenweg 162, Box 4.02, B-8400 Ostend, Belgium

Printed in Belgium by Reproduct NV, Ghent, Belgium
Gratitude Robot cover design by Felipe Ferreira, São Paulo, Brazil, re-produced by C-Design Bvba, Wielsbeke Belgium

EUROSIS-ETI Publication

ISBN: 978-94-92859-06-8
EAN: 9789492859068

SCIENCE FICTION PROTOTYPING CONFERENCE 2019

Preface

Dear Participants,

It is a great pleasure to welcome you to this year's SciFi It, the third International Science Fiction prototyping conference, which is being held at De Krook, from the 1st till the 3rd of April 2019. This conference is one of the few and quite unique in the world in looking at "what if" designs and technology out there on the event horizon of research, and how these can become real objects and tools within our human living space.

As our particular event horizon is Science Fiction, participants are most keen to learn from your specific approaches, how each and every one of you covered this transition of ideas and objects from science fiction into useful science fact tools.

This year's event hosts a number of excellent keynote and invited speakers. They are first of all Leonel Moura, European Ambassador for Creativity and Innovation by the European Commission, whose talk will be about "Taking the Human out of the Loop". Secondly we have, Ms. Alexis E. Block, from the Max Planck Institute for Intelligent Systems and ETH Zurich, whose talk on huggable robots is entitled "From Rosie to Baymax: Translating Our Most Huggable Characters To Real Life". Thirdly, Bram Vanderborght of The Brussels Human Centered Robotic Research Center who will give a presentation looking at robot-human collaboration entitled "Are humans and robots a strong team?". Our fourth invited speaker, Leon Rothkrantz of the Czech Technical University will give a presentation about "Smart Cameras in Smart Cities". Our fifth invited speaker Geert De Cubber of the Royal Military Academy of Belgium will give a talk on "Opportunities and Security Threats posed by new Technologies". And last but not least we have, our final invited speaker, Romulus Grigoras of Devatics, who will talk about future shopping in "Retail Apocalypse? From personalisation to omnichannelisation and beyond, innovation is shaping the future of retail".

Finally, we would like to express our gratitude to all other persons who have contributed to this event: firstly, to those who have submitted papers, and will present them over the next couple of days; to the tutors who will organize two tutorials during the event, and finally to the programme committee who have reviewed papers, and contributed to organising this event.

We hope that you will have a great time in Ghent, especially here in de Krook which in itself is a real architectural work of art, depicting in an abstract way, the sediment layers along the banks of the river it looks out of. De Krook, a location which houses, the Ghent public library, several high tech companies and several innovative research labs of Ghent University, working in the field of AR and VR. And finally we hope of course, that you will find the conference, to be an interesting and inspiring experience.

Ghent, April 2019

Philippe Geril
ETI
SciFi It General Conference Chair

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TAKING THE HUMAN OUT OF THE LOOP

Leonel Moura
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KEYWORDS
AI, machine creativity, non-human art.

ABSTRACT

Is it smart to try to make machines based on the human model? Since, first, we still know little about human intelligence and second, human behaviour is awkward, chaotic and often very violent. The insistence on this model is producing pathetic robots and frustrating AI solutions which are today almost reduce to commercial and military purposes. We need to free machines and robots from the human limited self-centred control domination. If we want to generate machine autonomy, not just in performance as well as able to evolve by its own means, we need a new vision.

TAKING THE HUMAN OUT OF THE LOOP

Ever since, humanity has dreamed of building machines at its image and behaviour. This documented venture combines fictional myths, such as the Golem or Frankenstein, with real automata built by the Muslim Al-Jazari, Renaissance Leonardo da Vinci or the swiss clockmaker Jaquet-Droz, just to mention a few. Until recently machines were mechanical, limited to a kind of gear predetermined choreography. But with the arrival of Artificial Intelligence machines are able to display unexpected behaviour.

However, most of their tasks are driven and controlled by humans. Which is understandable since machines are built for our service. In factories, multi-tasking or data mining this partnership produces good results. But when we aim at true machine autonomy the panorama is less favourable. One of the best examples is Sophia the robot from Hanson Robotics, although quite popular, is actually pathetic and in many aspects a hoax. Sophia just repeats, like a parrot, remarks previously introduced by Hanson engineers about typically human common sense and moralistic issues. Sophia is not an advancement in AI or machine autonomy but a regression towards a Frankenstein like robot. Even its ugliness and mediocre design confirms it.

In my work, as an artist, I have demonstrated that creativity is not an exclusive ability of humans but a natural mechanism that can be reproduced by machines. In such experiments the less I interfere the better. The behaviour of my painting robots is not based on a human model but instead of a more biological one, in the case the behaviour of ants and social insects. Working as a swarm they are able to generate abstract paintings not previously determined. Combining randomness with stigmergy the result is not entirely random. A different composition emerges from the interaction between the robots and the environment where clustering formation, that can be seen in most paintings like in Figure 1, is a sign of emergent composition.

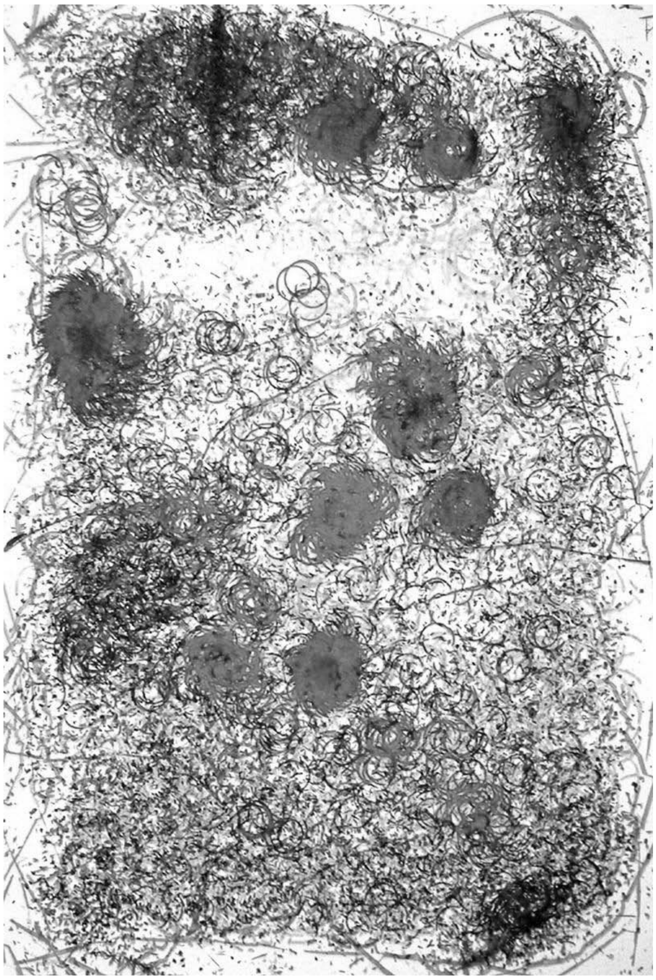

Figure 1: Artsbot, 010304, 2004, acrylic on canvas, 195 x 130 cm. Private collection

My approach is quite simple and applied to art questioning in the path of its particular history. After Kandinsky's abstraction that stated that art was about art itself; Duchamp's ready-mades that demonstrated that anything can be considered art by context or cultural consent; Conceptual art and the hegemony of the idea; machine creativity opens the path to Non-human art.

Translate to AI development such an enterprise proposes the possibility to remove the human from the loop and let machines evolve on their own. This idea may cause some distress and fears but it is unavoidable. If, for example, we consider space exploration there is no other way. Robots and machines that are launched in space, in long journeys, needto be able to survive and adapt. Proxima Centaury, in the constellation Centaury, the nearest star from the Sun is at approximately 4.37 light years distance. At the speed of current spacecrafts, it takes 80,000 years to get there. It is not foreseeable that, even in long term, humans can live so long or that we can increase space travelling so radically. For many centuries to come we will keep using machines to explore the universe.

In more earthly contexts machines able to take decisions and adapt are also necessary. For example, in Industry 4.0 and IoT. Machines that manage other machines need to be able to introduce design changes in the process. This will produce new generations of machines not dependent from human intervention.

Is it a risk? Yes. But the current situation is not satisfactory. We are reproducing in machines the same kind of negative behaviour witnessed in human societies. Violence, surveillance and control, discrimination, hierarchization. We are an irrational, conflictual and violent species. Not surprisingly the largest investments in AI and robotics are in the military field to produce killing machines. Which is really a very bad idea.

An AI that can evolve on its own may prove to be less dangerous than the one being developed right now by humans. In that course I anticipate three possible scenarios. The first and most probable, super intelligent machines will rather concentrate on their own evolution and drives and ignore human beings. With the exception of cats, dogs and parasites that is exactly what most of the other life forms do. The second possibility is that super intelligent machines establish a symbiotic relationship with us. Although this would be the best for humans it is not very probable in the long term since we have little to offer. The third is that we arrive at a conflictual situation, which can go from mild, making humans work for machines and not otherwise, to hard, leading to our extinction.

Do we still have time to favour the second scenario? Yes. But it would need a general upgrade in human intelligence and a substantial increase in social rationality. Looking at the sate of the world today it is doubtful that it will happen soon. In conclusion. The human model is not the best for AI development. Intelligent machines will keep on gaining autonomy until they can evolve on their own. When they achieve super intelligence, we don't know what may happen.

AUTHOR BIOGRAPHY

LEONEL MOURA is a European artist born in Lisbon, that works with the intersection of art, science and technology. In 2001 he created the first robot arm able to generate unique paintings operate by an 'ant algorithm'. In 2003 a swarm of 'Painting Robots' were able to produce artworks based on simple rules and emergent behaviour. Since then he has produced several artbots, each time more autonomous and sophisticated. RAP (Robotic Action Painter), 2006, created for the permanent exhibition at the American Museum of Natural History in New York, is able to generate highly creative and unique art works, to decide when the work is ready and to sign it, which it does with a distinctive signature. ISU (The Poet Robot), 2006, generates poems and paintings with letters and words. In 2007 the Robotarium, the first zoo dedicated to robots and artificial life, opened in Alverca. Other works include 3D sculptures, interactive installations, augmented reality, space art and the play R.U.R. from Karel Capek, with 3 robots performing aside 3 human actors, premiered in São Paulo in 2010. In 2009 he was appointed European Ambassador for Creativity and Innovation by the European Commission.

SMART CAMERAS AND SMART CITIES

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KEYWORDS
City Lab, Smart Sensors, Security, Smart Mobility.

ABSTRACT

A Smart City can be considered as an open living lab, where new technology will be developed, implemented and tested. The focus of smart cities in this paper is on the safety of citizens, sustainable energy, risk prevention of disasters, smart transport systems using information technology and Internet of Things. Smart cameras and smart sensor systems play a crucial role in smart cities. Citizens are surveyed by smart cameras, registrating their presence, their activities but also their needs and security. Big Brother is watching you, the Orwellian Nightmare come true.
In this paper we focus on the smart city of Amsterdam. At the entrance road of the city smart cameras register all entering vehicles; their license place will be recognized and checked for access in available databases. Similar smart cameras check car drivers for their access to the inner city and green zones. But not only car drivers are surveyed. Entering boats on the many waterways of Amsterdam are surveyed. Every vessel is supposed to have a transponder on board with an Automatic Identification System (AIS), enabling control of anomaly of shipping on the water and detection of intruders.
This paper is a survey paper of developed technology and research around smart cities.

INTRODUCTION

The concept of smart cities timulates development and tests of smart technologies, enabling better connectivity, safety and health environment of citizens. We will present automated access control of cities and their green zones by controlling cars at the entrance roads and monitoring ships on the water. Once cars and ships have entered the city they are tracked for anomaly of behavior by a network of smart cameras.
At this moment many cameras have been installed all over the city, attached to lamppost along the streets, at the entrance of many public domain building and houses, but also in side buildings. Schools and Universities are equipped with smart camera systems. Detection of people or objects is realized by software implemented in the camera. The cameras are connected via wireless networks including smart phone networks. But in the city of Amsterdam the wired network of electricity cables connecting streetlights are used.
A huge network is needed to transport all the sensed data but also huge computer power to process the data in a centralized or decentralized way. Cloud technology and deeplearning algorithm have been applied. The sensornetwork will be integrated with or completed by the network of human observers, connected via their smart phones.
Automatic assessment of human faces, license plates and identity codes are strict regulated by laws. Protection of the privacy and detection of suspicious behavior are competing with each other. Recent terroristic attacks, cybercrime call for more protection of civilians.

SURVEILLANCE SYSTEM BY SMART SENSORS

A key role in our omnivalent surveillance system is played by the smart camera and AIS (Hameete et al., 2012, Lefter et al. 2011, 2012, Rothkrantz, 013). They have been used to assess the identity of car drivers, identity of ships, anomaly detection of car driving and sailing. In the rest of the paper we discuss the following topics in more details:

Figure 1: Test bed road pricing system

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Automatic assessment of license plates.
At this moment many systems exist and are applied for traffic control. We developed our own system to be free of license control. The city of Amsterdam like many other cities suffers from traffic jams especially in the rush hours. At this moment car drivers are free to enter and leave the city according to their own time schedule. As a consequence many car drivers choose the same entrance and departure time. It can be

expected that distribution of arrival and departure time over the whole day will reduce the traffic jams. To realize that at the entrance roads and exit roads camera systems have been installed. Cabdrivers have to pay a fee at the entrance or exit of the city. The height of the fee depends of the time of the day. In one of the next sections we will provide more details on the Road pricing system.

Access control via the AIS system

Vessels can be detected and tracked via an Automatic Identification System (AIS). A ship sends AIS data to nearby ships, AIS base center and satellites. In our case a special AIS base station has been installed at the entrance of the port of Amsterdam. Access control, tracking and supervision of the sailing behavior are under control of the Coast Guard. Usually employees in a special control room supervised vessels 24/7. To reduce cost and human resources we developed an automated assessment and tracking system of vessels in the port of Amsterdam. A special traffic separation system have been developed and marked by buoys to control the incoming and outgoing traffic. The system has been tested at the military port of Den Helder.

Automated anomaly detection

Persons, cars and ships can be detected and tracked by smart camera systems. The tracks can be used for anomaly detection. First anomaly in behavior are violations of the traffic rules such as passing the speed limits, neglecting traffic signs, leaving lanes or trajectories or entering or stopping at forbidden areas or places. Driving without lights, car templates or switching off the AIS systems should be detected automatically. We developed knowledge based systems such as rule based systems, Bayesian networks and classifiers to detect suspicious behavior automatically.

SURVEILLANCE TECHNOLOGY

Automatic assessment of license plates

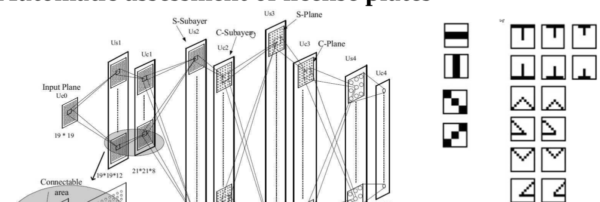

Figure 2: Architecture Neocognitron and training samples

Fukusima designed a complex hierarchical network to recognize handwritten digits (Cornett et al. 2003). The system was inspired by biological systems. The system was composed of 4 double layers. The first layer was able to recognize three pixels in different positions. The next layer was able to recognize more complex features composed of combinations of features from the first layer. In the final layer written digits were recognized.
We adapted that system to recognize license plates. In figure 2 we display the architecture of the system and some training samples for successive layers. Using deep learning technology our system has a good performance. In figure 3 we show the interface of our license plate recognizer. The recognition results are about 90% depending on location, position, weather and lighting condition. At this moment there are better systems on the market, but we preferred to have our system to perform experiments without violating license agreements.

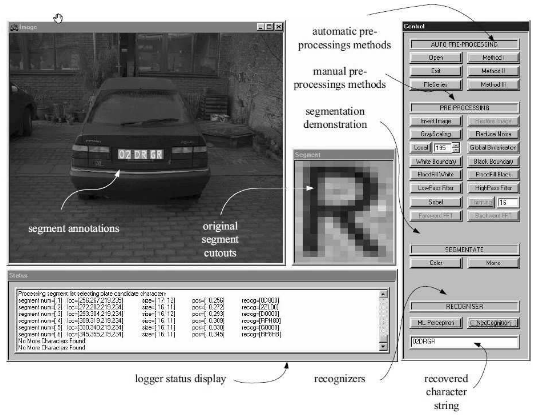

Figure 3: Interface of the license plate recognizer

Automated Identification System

Vessels have a transponder on board, sending data continuously. These data include information about the identity of the vessel, speed, heading and destination. The data can be received via the AIS system. There are a number of online data sources, such as MarineTraffic.com available that provide this kind of marine vessel traffic information. However, attempting to gather the needed data, use these services can be problematic. The first problem is one of data density. If the data density is low, which is the case for the open source services, this means that position reports are sometimes 30 minutes too late and thus miles apart (Rothkrantz et al., 2013, Scholte et al, 2014). The second problem with using an open source like Marine Traffic.com is that the accessible information has gone through a lot of preprocessing. We decided to gather the AIS data ourselves.

Figure 4: VHF antenna attached to a tower and AIS Receiver

SURVEILLANCE SYSTEMS AND THEIR APPLICATION

Smart camera systems at the entrance roads of the city of Amsterdam enable us to detect which cars are entering the city of Amsterdam (Rothkrantz, 2009, 2014, 2017, 2018). At the entrance an agent is attached to an entering car. All these agents compose a huge system of Multiple Agent Systems (MAS). The autonomous agents are detected and tracked through the city via a network of smart cameras attached to lamppost and buildings. Anomalies of car driving are:

- violations of traffic rules (exceeding speed limit, drive through red light, sticking to the bumper, crashes of cars)
- detection of persons suspected from criminal activities (stolen cars, terrorists)
- drivers with open penalties
- wanted drivers, searching the whole network of smart cameras.

Vessels will be detected at the entrance of the port of Amsterdam and tracked via AIS. Anomalies in sailing behavior will be detected such as:

- entry into limited access area
- slowdown or stop in traffic separation system collision between vessels
- entering, exiting, crossing a separation system

In figure 6 we display the reasoning system of the smart cameras. After capturing a sequence of images, features will be extracted such as position, speed heading and change of these features. A hypothesis will be defined and validated or rejected using a rule based or Bayesian reasoning system as displayed in figure 5, 7.

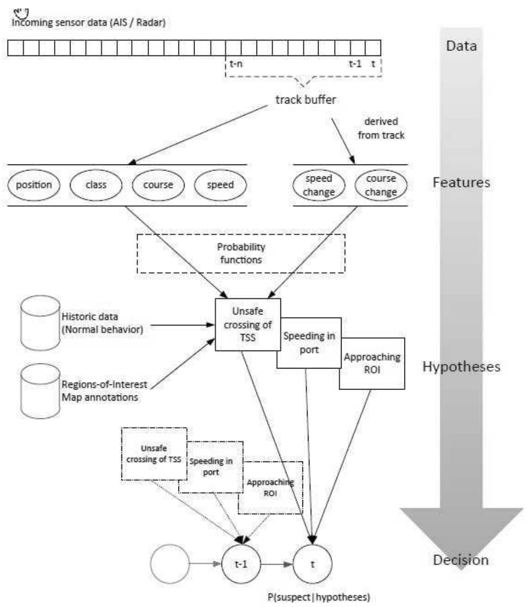

Figure 5: Global processing scheme detecting anomaly

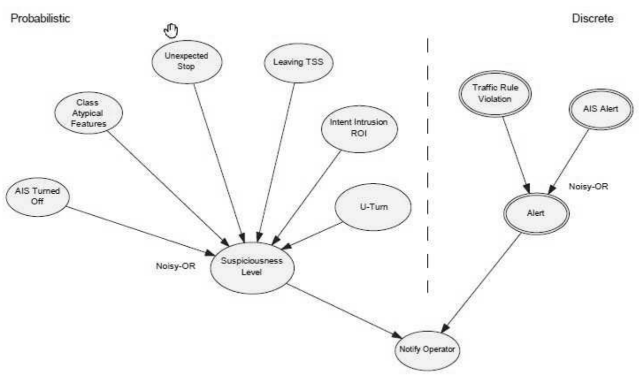

Figure 6: Model of Bayesian network for detection of suspicious behavior

This node is a noisy-OR node and represents the probability of a vessel acting suspiciously. Its state values are determined by the probability of the parent hypothesis nodes. The values of the CPT were determined on the basis of expert opinions.

Table 1: Probability table of suspicious level node

Parent	Leaving TSS	AIS Turned Off	Class Atypical Features	Intent Intrusion ROI	Unexpected Stop	U-Turn	LEAK
State	Leaving	AISoff	Abnormal	Intrusion	Stopped	UTurn	
Suspicious	0.8	1	0.7	1	0.8	1	0
NotSuspicous	0.2	0	0.3	0	0.2	0	1

Note that the model has two groups of nodes: one with normal probability nodes and one with "discrete" nodes. This was done because the system should be able to handle interrupting discrete (nn-probabilistic) events as well. An example of such an event is the AIS alert message. This message is send by a vessel that is in distress. The most common of these is the NUC message when a vessel's crew is no longer in control of the vessel movement, e.g. due to engine or rudder failure.

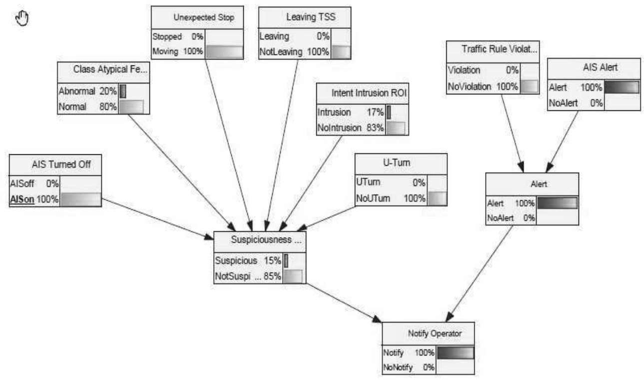

Figure 7: The model observing a vessel with an AIS alert.

Operators act according to processing information model as is shown in figure 8. We distinguish three types of processes: a skill based track, a rule based flow and a knowledge based flow.

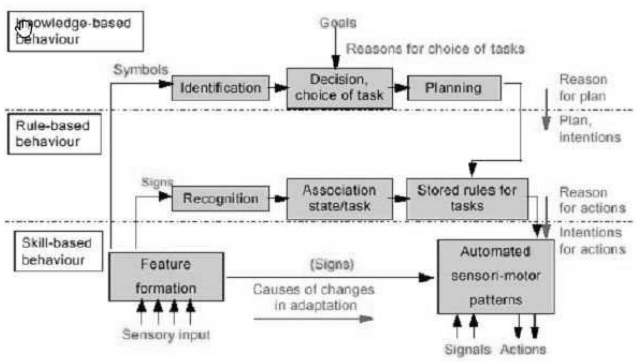

Figure 8: Simplified model of traffic monitoring

IMPLEMENTATION OF SURVEILLANCE SYSTEM

Our goal was to design and implement a surveillance system of cooperative smart cameras distributed over the city. The system should be able to localize and track car drivers automatically and detect suspicious behavior by hierarchical reasoning. Every smart camera has been modelled as an agent. The whole system of cooperative multiple agents has been implemented using JADE and CLIPS for automatic reasoning. The system has been tested using different scenarios and test environments. Results are presented in (Eigenraam et al. 2016). In this section we outline the general design of the system used tools, and its architecture.

Our system is composed of intelligent cameras which have reasoning and communication capabilities. Since all the agents process information and communicate in a similar fashion, the generic Guardian Agent base class was developed to supply each of them with the framework to perform these actions. The added features include the pipeline structure, data and event logging and the services support system.

Guardian Agent services are asynchronous procedure calls that are made available to other agents. A layered encoding system build on top of the existing communication method provided by JADE allows procedures to be called remotely. Each agent can support different services. The services are registered with the agent's service system, which will manage the triggering of call events and sessions during runtime.

There are five different types of agents: Alerting Agent, Delegation Agent, Global Reasoning Agent, Local Reasoning Agent and Regional Reasoning Agent.

The processing pipeline for the automatic behavior detection system runs through the local, regional and global agents.

Starting with the agents connected to the cameras, each agent processes the available information and passes it on to the next process, creating an information flow. The local agents provide the local track data, which the regional agent subscribes to using the tunneling mechanism.

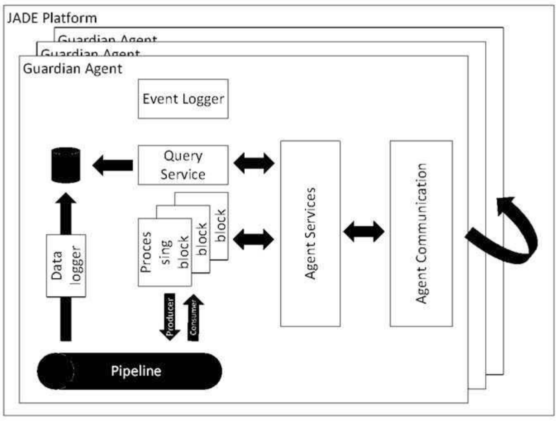

Figure 9: Agent components

The updates received by the regional agents are stored in the agent's memory and historical values are managed within the agent, based on the functionalities of the agent. New features extracted by the regional agents in turn are provided to the next layer of agents and finally end up in the global agent.

In our suspicious behavior classification processing pipeline, agents perform five tasks: detect, map, recognize, extract features and reason. The relation between these agents has been designed as a hierarchical model, where each higher level gains a more global image of the car's behavior, as shown in figure. 9. Reasoning is performed at multiple levels and distributed over different agents.

Conceptually each agent has an area which it will have to guard. The larger the area, the more complex the behavior of the cars will be. This will create a bottleneck at the agents responsible for large areas. The bottleneck is counteracted by reducing the complexity of the information, for example with samples of lower frequency and resolution of the input. Local agents look at high resolution images with a high frequency, while global agents look at almost binary detections with low frequency over the sub-regions.

Each agent receives a series of images over time. The pipeline starts with detecting the cars in the image. The detection uses our license plate recognition system. Once the cars detections are known, the image coordinates have to be mapped to the environments coordinates. In real world environments, the mapping step requires the mapping of both the two dimensional image to three dimensional world and the relative location of the camera to the other cameras.

Once multiple detections are made, the detections must be combined to form a track. The recognition algorithm is applied for every new detection in the camera image. It uses the behavior of each track to select the most likely track for new detections, including the option of creating a new track. The final processing step extracts additional information about the track. The parameters calculated based on the track are used to classify the behavior of the car. The local feature extraction calculates the following features from the track: location x,y, heading, speed x,y, speed turn, acceleration x,y, duration.

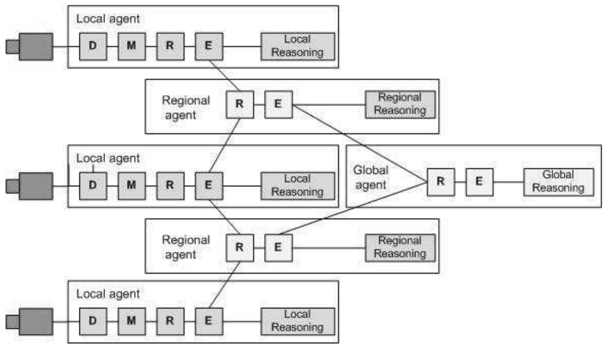

Figure 10 : Agent roles and communication

The regional agent analyses behavior over a small region with multiple cameras. It combines local tracks, forms regional tracks and analysis the behavior detectable within the scope of the cameras. Thanks to the cooperation between the guardian agents, the regional agent does not need to perform the same processing steps as the local agent. Several local agents go through the detection and tracking process as described before. The same local track information that is used for local reasoning is also send to the regional guardian agent. The communication between the agents is done using a combination of a pipeline and subscription technique.

The global information process highly resembles the regional information process. It combines the track from the different regions to one track through the complete region. Every new step in this track combination process loses more detail and tracks are considered with a lower resolution. The decrease in resolution also decreases the bandwidth of the data streams and avoids the bottleneck on the global agent's data stream. For this reason, the global information process.

connects region tracks. The tracks are combined using a probability model, including knowledge of the environment.

A commonly used technique in software testing is the use of mocking classes. The mocking classes perform the same actions as the real implementation would perform. By calling functions, the mocking classes check if the components under testing produce the expected results or can check if the components under testing call functions at the right time (and with the right parameters). The mocking classes themselves form no useful aspect of the final product, but can give insight in the functionalities of the components under testing.

Mock agents (MA) form a similar addition to the multi-agent system. Although they do not add anything to the functionalities of the multi-agent system, they communicate with the agents under testing (AUT) using the same methods the AUT use. The AUT have no method to check if the system is used for testing or for real environment. It processes the information as normal. The mock agents in turn can validate the information from the AUT and notify if the test has passed or failed.

Mock agents solve the problem of autonomously of the AUT, but the MA are agents themselves and by design are autonomous. We need a method to listen to the MA to check their conclusions and possibly set parameters. JADE does provide a method to do so.

Our design of the multi-agent unit testing environment uses two types of mocking agents: actors and quality control agents. The actors only pretend to be agents that in the real environment would communicate with the AUT. They are used to trigger an event in the AUT by communicating the scripted messages. The Quality Control Agents (QCA) validate the result. Every QCA is responsible for performing one or more tests and validate if the messages from the AUT contain the expected information. A multi-agent unit test succeeds when all the QCAs report a success in there tests. The UML Class diagram of the mock agent design is shown in Fig. 11.

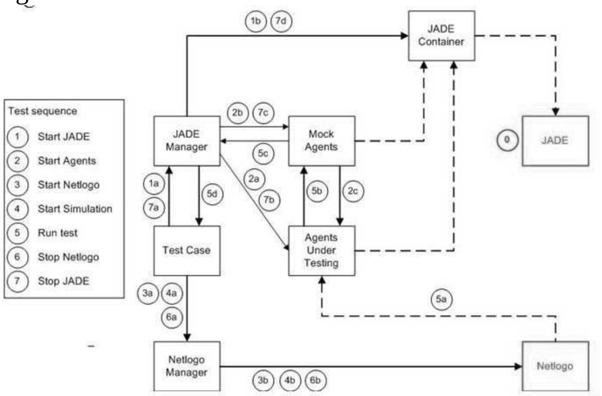

Figure 11: UML Class diagram mock agent design

CONCLUSIONS

One of the goals of the Councils of smart cities is to guarantee the safety of its citizens. In a pilot project "Smart Sensor City" this has been realized by a network of smart sensor cameras. At the entrance roads of the city cameras are installed to monitor and control incoming cars via automatic license plate recognition. If a license plate on a list of suspicious people, access of the car driver will be denied. Smart cameras are also installed in lamppost along the streets. Cars will be detected and tracked. Via analysis of the tracks anomalies in car driving will be detected and car drivers penalized.

The access of many cities in the Netherlands is controlled by Coast guards. In our project the human surveillance system has been replaced by an automated systems based on AIS. Anomalies in sailing behavior at the port and canals will be detected automatically and the captains of corresponding vessels will be penalized.

In fact we have realized a monitoring system modelled after "Big Brother is watching you". The Council of the city has to guarantee that the privacy aspects of people will be guaranteed and the system satisfies the legal rules.

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OPPORTUNITIES AND SECURITY THREATS POSED BY NEW TECHNOLOGIES

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KEYWORDS
Augmented reality, unmanned aerial systems, drones, unmanned maritime systems, unmanned ground systems, societal acceptance.

ABSTRACT

The technological evolution is introducing in a fast pace new technologies in our everyday lives. As always, these new technologies can be applied for good causes and thereby give us the opportunity to do many interesting new things. Think for example about drones transporting blood samples between hospitals. However, like always, new technologies can also be applied for bad causes. Think for example about the same drones, but this time transporting bomb parcels instead of blood.
In this paper, we will focus on a number of novel technologies and discuss how security actors are currently doing their best to maximize the "good" use of these tools, while minimizing the "bad" use. We will focus on research actions taken by Belgian Royal Military Academy in the domains of:

- Augmented reality, and showcase how this technology can be used to improve surveillance operations.
- Unmanned Aerial Systems (Drones), and showcase how the potential security threats posed by these systems can be mitigated by novel drone detection systems.
- Unmanned Maritime Systems, and showcase how this technology can be used to increase the safety at sea.
- Unmanned Ground Systems, and more specifically the autonomous cars, showcasing how to prevent potential cyber-attacks on these future transportation tools.

INTRODUCTION

Advances in micro-electronics and robotics are changing our society. New technologies like unmanned vehicles and augmented reality are being introduced very rapidly. Like all technologies, these can be used for good or for bad purposes and it is up to the public society to drive the societal acceptance of these technologies and up to the policy makers to create a legal framework that allows for a fair and responsible use of these new technologies. However, the fast pace in which these new technologies are introduced makes it very hard for the general public to evaluate the advantages and disadvantages of these technologies and also makes it very difficult for policy makers to adapt the legal framework to the latest evolutions. This creates a tension field between technology enthusiasts – who want to introduce these new technologies as soon as possible and sometimes neglect the societal, safety and security implications this may have – and technology conservatives – who tend to want to over-regulate novel technologies, thereby impeding their chances to mature.
Indeed, each new technology provides new opportunities, but also new threats, which then leads to other new policies or technologies that have to be developed to mitigate these threats. This paper confronts this problem by developing 4 use cases where each time a different new technology application is showcased (augmented reality, unmanned aerial vehicles, unmanned maritime vehicles and unmanned ground vehicles) and where a different aspect of the opportunities-threats-mitigation – spectrum is focused upon.
The use cases developed in this paper are based on different research actions performed in the Belgian Royal Military Academy and therefore have as application domain the broad security sector.
The objective of this paper is not to scare the reader about the security threats tied to new technologies, but to provide a balanced discussion for each of the technology areas, in order to provide the reader an insight in the advantages of each of the discussed technologies, the associated security threats that may hamper societal acceptance of the technology and the mitigation actions that are currently being under development in order to provide answers to these security threats.

AUGMENTED REALITY: HOW TO USE THIS TECHNOLOGY TO IMPROVE SURVEILLANCE OPERATIONS?

Opportunities

Security and surveillance agents have to correctly interpret any suspicious acts or anomalies and act swiftly upon confirmed threats in a coordinated manner. This is a tremendously difficult task, as these agents:

- are confronted with an overload of information, certainly as they are often surveilling densely populated areas

- have to decide upon a coordinated action plan in a minimum of time, as terrorist attacks have proven to be carried out very quickly

- have to proceed with extreme caution when entering into action, as they are working in theatres with many civilian bystanders.

Technologic aids to assist security and surveillance agents in each of these phases of the sense-plan-act decision chain have been developed in labs, but - apart from the wireless communication area – there have been few technologies that have been really successful in showing an operational advantage on the field for these kinds of applications. This is mainly due to the extremely short reaction time required, which voids the use of classical management and coordination tools (as even using tablets would distract the surveilling agent from the threat/target). However, with the advent of wearable augmented reality technology becoming more mature, portable and accessible, this situation is changing now. Indeed, augmented reality provides a paradigm for superimposing in real-time important information to the view-field of the security and surveillance agents (Azuma 1997), thereby enhancing the current perception of the reality by superimposing computer-generated sensory data, such as graphics, video, GPS data, …. A crucial aspect is of course the human-system integration and the selection of the ‘augmented’ information to be presented.
In order to capitalize on these potential benefits augmented reality technology can bring to security professionals, the Belgian Royal Higher Institute for Defence has decided to fund a research action that aims to develop these technologies. The envisaged solution of this research project has the following objectives:

- Enhance the security agent sensing capabilities by showing data from available mounted and dismounted sensors (video, thermal, potentially also from drones) in order to allow the agent to see around occlusions (e.g. across a corner or inside a building), as depicted on Figure 1.

- Enhance the security agent’s planning capabilities by providing a continuous location information on teammates and a continuous communication channel with these teammates, including routing support in order to get to intervention locations quicker, as depicted on Figure 1.

- Preserve the security agent’s existing intervention capabilities by ensuring a well-thought human-system integration that respects the security agent’s requirements towards system portability and unobtrusiveness.

- Enhances the security agent’s intervention capabilities by providing an augmented reality training program, wherefore augmented is particularly suited, as trainees see each other through their natural vision, as opposed to virtual reality.

Figure 1: Concept sketch of see-through-wall user interface and localization & planning user interface

Threats

The main threat to society related to augmented reality lies in the privacy and data protection issues related to the use of the technology. Indeed, in China, the government has already begun (EDPS 2019) to roll out augmented reality glasses with automated face detection that enable police officers to automatically cross-reference faces against a national database, and single out suspects and criminals. One of the controversial aspects of this augmented reality system is that whenever the police officers are confronted with an individual, they now immediately get informed about a whole series of sensitive personal data, including the divisive social behaviour score. This means that there is a serious risk of bias by the police in the approach of individuals, which would be detrimental to the fundamental rights of each citizen. This example shows that, whereas this type of augmented reality application could be used for good uses, the risks are high. Human rights activists and data protection services have already warned (EDPS 2019) that using augmented reality technology in combination with large centralized databases containing sensitive personal information is a serious potential threat to the freedom of thought. Moreover, the data protection of sensitive personal information streamed from and to the augmented reality device (which is small and mobile and can thus be easily stolen) cannot be 100% guaranteed.

Threat mitigation

In response to the ethical concerns related to technology discussed above, it was decided not to include aspects of face mapping to a central database into the research study of the Belgian Royal Higher Institute for Defence. While this is potentially a high-value application of augmented reality technology, the privacy impact is considered too high and as long as this issue is not tackled and as long as the data protection cannot be guaranteed, it would be dangerous to field such a technology at wide scale.

UNMANNED AERIAL SYSTEMS (DRONES): HOW TO DETECT DRONES WITH MALICIOUS INTENT?

Opportunities

Recent advances in technology have rendered unmanned aerial systems (commonly referred to as drones) affordable, accessible and easily controllable by novice users. Together with the liberalization of the legal framework (which is still on-going), this has sparked the uptake of the technology for recreational use, but also for commercial use. Multiple good causes can also be referenced where drones are used for the benefit of the society, such as search and rescue (De Cubber et al. 2013) or humanitarian demining (Yvinec et al. 2012).

Threats

The enormous potential of unmanned aerial systems has unfortunately also already sparked the interest of malevolent individuals who use the technology for criminal or terrorist use (Buric and De Cubber 2017), e.g. for terrorist attacks, activism, drugs and human trafficking, privacy invasion, etc. The main problem with present-day drones is that they have become so small and agile that they virtually impossible to detect by classical detection methodologies for aerial threats (which is typically a RADAR installation). Furthermore, as the drones become more and more capable, it becomes possible to carry potentially hazardous payloads and to perform sophisticated attack operations, even with very cheap and commonly available drone platforms.

Threat mitigation

In the longer future, it will likely become mandatory for commercial drones to be registered and the systems will likely automatically register themselves (e.g. via the 5G network) with a sort of unmanned traffic management system (Lundberg et al. 2018) before taking off. This approach would resolve suite a lot of issues with recreational users unknowingly performing illegal flights.
However, an unmanned traffic management system will not solve the problem of criminals wilfully using drone technology for bad causes. Indeed, drone development kits and open-source autopilots are commonly available. As a result, it will always be possible for individuals to develop their own drone systems and by doing so bypass the mandatory registration (which is e.g. much harder when it comes to cars and regular aeroplanes). For this reason, it is required to develop a drone detection capacity.
Several detection modalities are being researched to tackle this problem: RADAR (Li and Ling 2017), LIDAR (de Haag et al. 2016), Acoustic Sensing (Mezei and Molnár 2016), Radio Sensing (Sit et al. 2016), thermal and visual sensing. As no individual sensing modality attains satisfying levels of accuracy, a combination of approaches is often used.

The most common drone detection systems are based on the RADAR sensing technology. These drone detection systems are in fact evolutions of former bird detection RADAR installations on airports that were specifically tweaked to be able to single out drones instead of birds. However, the problem with these RADAR-based drone detection systems is that they are generally quite expensive, whereas the detection range stays relatively low. As a result, the economic viability of deploying these RADAR-based drone detectors on a wide scale for protecting a large area is at this moment still questionable.
The European Commission noted this capability gap and decided in 2016 to fund the H2020-SafeShore project (De Cubber et al. 2017). The SafeShore core solution for detecting small targets that are flying in low attitude is to use a 3D LIDAR that scans the sky and creates above the protected area a virtual dome shield. In order to improve the detection, SafeShore integrates the 3D LIDAR with passive acoustic sensors, passive radio detection and video analytics. Compared to the more traditional RADAR-based detectors, all those technologies can be considered as low cost and "green" technologies, as the sensors do not emit in the radio-spectrum. The SafeShore detection system, shown on Figure 2, was implemented as a proof setup for maritime border security, detecting maritime border infringements (e.g. by human and drug traffickants, but also by terrorists) coming from over sea. The SafeShore system was validated (Doroftei and De Cubber 2018) in 2018 using three validation campaigns in the North Sea, the Mediterranean Sea and the Black Sea, showcasing that the combination of orthogonal technologies used (LIDAR, passive radio, acoustic and video analytics) show a true potential for complementing the traditional RADAR-based solutions. However, like the RADAR-based solutions, also the SafeShore system currently still has to solve many issues related to limited range and relatively high cost (be it lower than RADAR), posing bottlenecks for wide-range adoption.

Figure 2: SafeShore drone detection system installed on the beach in Belgium during the SafeShore North Sea trial
Picture by Daniel Orban

Obviously, detection is only one first step in the complete counter-drone response chain. Effective classification, identification and even neutralization means are also required in order to provide a holistic response. In each of these areas, research is under way in order to provide responses. The main difficulty here lies in developing solutions that are also applicable in dense urban areas where there are many other legitimate drone users of the airspace or innocent bystanders that shouldn't be disturbed, rendering solutions like non-directive radio or GPS jamming & spoofing and kinetic approaches impossible.

UNMANNED MARITIME SYSTEMS: HOW TO USE THIS TECHNOLOGY TO INCREASE THE SAFETY AT SEA?

Opportunities

Unmanned maritime platforms are now becoming more and more a mature technology. They are increasingly used by law enforcement agencies worldwide and are forecast to grow quickly over the next decade. In the US, unmanned maritime platforms were identified as a key enabler for maritime security and electronic surveillance. In Europe, the European Defence Agency has explored their use for military applications and identified long term deployment, mission planning and interoperability as the key issues to be tackled for their routine use for maritime surveillance operations.

The aim of maritime surveillance is to understand, prevent (where applicable) and manage the actions and events that can have an impact on Maritime Safety and Security, search and rescue, accident and disaster response, fisheries control, marine pollution, customs, border control, general law enforcement and defence, as well as on the economic interests. To date, this has been undertaken using satellites (remote sensing), aircrafts and manned ships equipped with a variety of sensors, from radars to thermal imagery. Unmanned Maritime Systems have the potential to provide significant benefits to bodies involved in maritime surveillance.

First, they can provide round the clock operations and remove the human from the operating scene. Second, their low-cost compared to currently used manned assets makes them suitable as a force multiplier to enhance and, in the longer term, replace existing maritime platforms. Finally, with suitable embedded intelligence, they can be used collaboratively for complex surveillance tasks on a large scale.

New developments in solar and wind powered systems pave the way for the more permanent deployment of unmanned maritime systems and makes them ideal as host platforms for other unmanned assets such as Unmanned Underwater Systems and Unmanned Aerial Systems with more limited autonomy.

Another reason that unmanned maritime platforms are so ideally suited for maritime surveillance is that they typically have a low radar and heat profile and can approach and qualify potential illegal activities safely and effectively while potentially staying undetected until other assets can be deployed.

They can also be used to deploy complementary sensors, either mobile such as Unmanned Aerial Systems, Blimps and Unmanned Underwater Systems to enable a very wide variety of sensors to work collaboratively. Uniquely, they can detect maritime targets with low profiles such as rubber boats and submersible or semi-submersible vehicles and can thus be deployed in various scenarios, e.g. the fight against piracy, smuggling and illegal fishing or used as a screen against hostile operations or for safeguarding shipping and sea lanes.

Threats

As unmanned maritime systems are mostly employed at sea, they come less into contact with the general public and there are less security and societal acceptance issues to be solved that may hamper a wide-scale adoption of the technology, compared to unmanned ground and aerial systems. This is also the reason why unmanned maritime systems are much more mature in terms of autonomy features compared to their aerial and ground-based siblings, even though this may be much less visible to the general public.

This also means that more and more of these vehicles are being deployed in the field, each with their own characteristics and specifications. This variety of systems is now starting to pose interoperability problems when deploying multiple of these unmanned maritime systems together for operations, as there is to date no unified command structure for these unmanned assets and there are also no standardized data interchange platforms that allow for an easy transfer of sensory information from one platform to another. The result is that commanders of unmanned maritime systems have to work in most circumstances with custom-built solutions that may be good in performing one task well, but that encompass little flexibility and modularity towards upgrading the task description for future needs or towards interoperability with other deployed assets.

Threat mitigation

Responding to the increasing problems related to interoperability in the domain of unmanned maritime systems, the Belgian Royal Higher Institute for Defence has decided to fund a research action that aims to develop a heterogeneous interoperability and collaboration framework which is seamlessly interoperable with the existing and future C4I and GIS infrastructure. The interoperability concept consists of a highly modular system of carrier platforms and payloads like the systems depicted on Figure 3, enabling straightforward switching of payloads from one system to another.

Figure 3: Two Unmanned Maritime Systems (fast mothership carrying a rescue capsule) for search and rescue operations (De Cubber et al. 2013)

UNMANNED GROUND SYSTEMS: HOW TO PREVENT CYBER-ATTACKS ON OUR FUTURE AUTOMATED CARS?

Opportunities

The scientific advances made in the field of robotics have led to an increase in the number of unmanned ground vehicles used. Two main application domains are currently using unmanned ground vehicles in large numbers. On one hand there is the military, where they are used as Explosive Ordnance Disposal robots, search and rescue robots or demining robots. On the other hand, there is the application field of distribution and warehouse automation, where whole large-scale warehouses see a transformation from traditional human-led pick & place operations towards automated services provided by robots.
In this section, we will however develop and discuss another type of unmanned ground vehicle: the self-driving cars. When discussing self-driving cars, it is important to distinguish the 5 levels of automation for these vehicles, going from 0 (no automation) to 5 (fully autonomous in all areas under all roadway and environmental conditions). Currently, some manufacturers provide autopilot systems that are capable of reaching level 2 (partial automation, e.g. on motorways) and in research level 4 can even be attained, where the system only needs to fall back to a human in exceptional cases. Even though there are today no truly fully autonomous self-driving cars on the market (which would mean level 5 automation), the market potential for these types of vehicles is huge and so is the potential disruption they can cause to society. Therefore, several (mostly all) car companies and many technological giants like Google are currently developing self-driving cars, as shown on Figure 4.

Figure 4: Waymo self-driving minivan during testing (Picture by Dllu [CC BY-SA 4.0])

The potential benefits to society of self-driving cars are huge. In the first place, there is the safety argument. Indeed, in many developed countries, road accidents have become the most prominent cause of death for young adults (20 to 40 years) and self-driving cars hold the promise to bring down that number of deaths significantly. Even though autonomous driving cars can become safer than humans driving cars, this promise shouldn't be taken for granted, it still needs to be proven, and it should also be very clear to everyone that bringing down the accident rate to zero is not realistic.
Furthermore, self-driving cars bring with them the promise of mobility as a service, where car ownership is no longer necessary, but people can hail self-driving taxis whenever they need them. This would also void the need for garages and parking spaces that take up enormous amounts of public space in our cities (and homes), making room for more a useful application of that space.

Threats

The potential threats posed by self-driving cars are multiple. First, these vehicles rely on multiple sensors in order to avoid obstacles and interpret the situation on the road. The most common sensing technologies include RADAR, LIDAR, and cameras. The issue is that each of these sensors have their specific failure modes, i.e. situations where they totally misinterpret the situation, which could lead to deadly accidents.
Concerning RADAR systems, researchers have shown a technique (Yan et al. 2016) to fool the system into perceiving an object where none existed, leading to dangerous evasive manoeuvres. Concerning the LIDAR, researchers have demonstrated (Shin et al. 2017) two kinds of attacks: a spoofing attack, and a saturation attack. While both LIDAR and RADAR hacks do require some specialist equipment, cameras can be fooled much easier, by putting stickers on street signs. Researchers (Eykholt et al. 2018) analysed the machine learning algorithms used by the cars and applied a number of different attacks to manipulate signs in order to trick machine learning models into misreading them, applying some small stickers to trick the vision system an autonomous car would use into reading a stop sign as a 45-mile-per-hour sign, which could lead to accidents.

A whole different threat is related to data and privacy protection. Indeed, the improvement in the autonomy of self-driving cars depends on the continuous feedback and improvement of the machine learning algorithms that are fed data from the car's sensors. This entails that the self-driving cars constantly send – potentially sensitive – data acquired by their sensors to the manufacturers, which is a data protection risk.

Threat mitigation

There is only one possible solution to the problem with the individual failure modes of the different sensors: redundancy. Indeed, like in the aircraft industry, it will probably become mandatory for future self-driving cars to use different, redundant and independent sensing modalities in order to be "roadworthy". Using novel sensors (De Cubber et al. 2011), multi-modal sensor combinations (De Cubber and Doroftei 2011), and intelligent data fusion it is possible to recover from failures from individual sensors and build up a robust environmental picture in all circumstances. It needs to be noted that this demand for redundancy comes at a cost: it means that all self-driving cars will have to be equipped with multiple expensive sensors and probably also with multiple expensive processing stations, which means that the cost for a self-driving car will probably be high (which may become less of a concern as car ownership will probably no longer be required).

CONCLUSIONS

Within this paper, we have discussed four novel technologies (augmented reality, unmanned aerial vehicles, unmanned maritime systems, self-driving cars) and how they can impact our society: what opportunities lay ahead of us, but also what threats these new technologies pose to us and what can be done to mitigate these threats. In all of these four areas, the Belgian Royal Military Academy is active in providing solutions to promote and increase the "good" use of the technology and to prevent the "bad" use. By doing so, we hope to promote the societal acceptance of these technologies and to contribute to a safer and more secure world.

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AUTHOR BIOGRAPHY

Geert De Cubber received in 2001 the degree of Master in Engineering at the Vrije Universiteit Brussel (VUB), with as specialization Electro-Mechanical Engineering. He then obtained a PhD. for his research in the field of 3-

dimensional reconstruction of natural scenes perceived by mobile robots. This PhD. and the associated research project were part of a joined research effort between the Vrije Universiteit Brussel and the Belgian Royal Military Academy (RMA).
Currently, Geert De Cubber is a researcher working in the department of Mechanics of the Royal Military Academy, where he is leading the research activities of the research group on robotics for high-risk applications. The specialization of this research unit is the development of unmanned vehicles (aerial, marine and ground robotic systems) for high-risk applications like search and rescue and humanitarian demining. Within the group of Unmanned Vehicle Centre, Geert's main task is to apply computer vision techniques to mobile robots, rendering these robots able to perceive, analyse, and – to some degree – understand their environment. More specifically, three-dimensional reconstruction and cognitive vision approaches are investigated with the aim to port the capabilities of the human eyesight to intelligent robots
Currently, Geert is the coordinator of the EU-H2020-SafeShore project which deals with the development of novel detection system to cover existing gaps in the maritime border security system. The main focus of this project is to find detection means for small unmanned aerial vehicles (drones), which cannot be detected by present-day security installations.
Previously, Geert was the coordinator of the EU-FP7-ICARUS project which dealt with the development of unmanned tools (aerial, ground and marine robots) which can assist search and rescue workers to save human survivors after a major crisis (earthquake, tsunami, typhoon, shipwreck, …).

TUTORIAL

E-COMMERCE PERSONALISATION UNDER THE HOOD: BUILDING A SCALABLE, VIRTUALIZED PLATFORM WITH MILLIONS OF EVENTS HANDLED IN REALTIME

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KEYWORDS
Personalisation, E-Commerce, Omnichannel Strategy, Scalable and Virtualized Architecture.

ABSTRACT

This two-voices tutorial will be given according to the outline.

Introduction and Motivation

In this tutorial, we first define the web personalisation problem (Baccot et al. 2009) and we introduce the specifics in the e-commerce case (Baccot et al. 2011). We explain why a big data architecture is required to handle millions of events in real-time if we want to deliver an unique browsing and shopping experience to each customer. Both the scientific bottleneck and the technical constraints are precisely identified.

Proposed Architecture And Related Works

We describe the virtualized platform designed at Onestock/Devatics starting from 2014 to tackle these general challenges. We position this architecture proposal against state-of-the-art solutions and shows its novelty. Both the original databases infrastructure (combination of OLAT and OLDT systems, as shown in Figure 1) and our microservices based architecture (as depicted in Figure 2) still resist to the exponential growth of the personalisation needs at large scale.

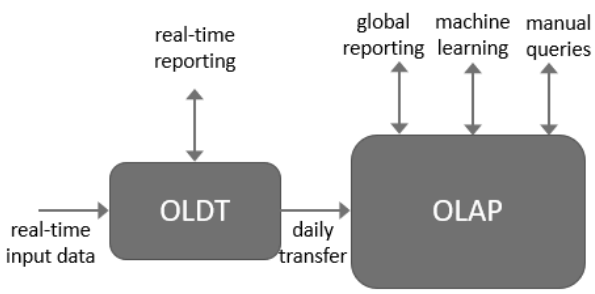

Figure 1: an Overview of our Architecture, Combining OLDT (OnLine Database Transaction) and OLAP (OnLine Analytical Processing) Systems.

Indeed we anticipated in 2014 several trends and key ideas that are now observed in the literature (Neves et al. 2016), (Dragoni et al. 2017). Neves, for instance, puts stress on the scalability that is triggered manually rather than automatically in most of the case. He promoted, in 2016, an automatic scalable system with both reactive and proactive aspects which was exactly our 2014 approach. We eventually show the implication of our choices. Our new architecture has been operating for several years as a massive personalisation tool and now implements new omnichannel functionalities.

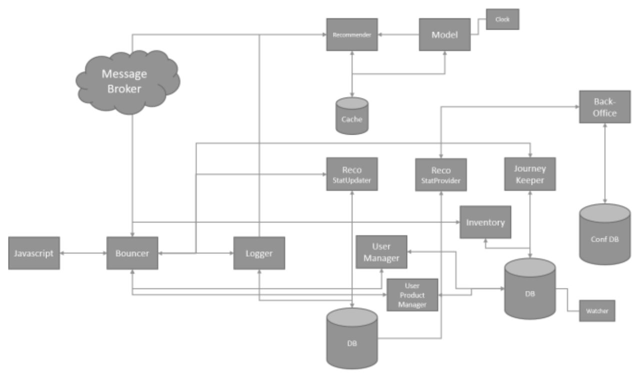

Figure 2. a Simplified View of our Microservice Architecture. Each Component Represents a Replicated Mono-Functionality Service.

From Personalisation To The Omnichannel Delivery Promise

We go one step further and show that correlating the behaviors of shoppers across different channels and taking into account available stocks and product characteristics leads to the future delivery promise. Both the order management across channels (assessment of shipping costs/delays) and the web-to-store marketing tools (recommending in store what has been visited online) also require real-time predictions and reactions. We explain why our architecture is general enough to support solutions to these booming issues.

Generalization

Interestingly, we finally step back to show that big data problems triggered by the (r)evolution of retail and e-commerce can be straightforwardly transposed to other applications areas. We concentrate on two examples: personalized e-health (Zhang et al. 2005) and personalized assistance (Cook 2006). Again, we briefly define these emerging applications and related research problems to show that there is a perfect match between the architecture requirements coming from the e-commerce or the e-health/assistance domains. The key idea is that the Internet of Things (IoT) and so many (wearable) sensors will also trigger the exact same "millions of events in real-time" (Hassanalieragh et al. 2015). Continuously captured, aggregated and interpreted the e-health or assistance related events form a similar stream of temporalized events as observed in our e-commerce use case. We eventually elaborate on the similarity between predictions, decisions and reactions in both areas before concluding with the most general lessons learnt.

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SCIENCE
FICTION
METHODOLOGY
AND
VR

ARCHITECTURE OF A VIRTUAL REALITY-BASED TOOL FOR THE SUPPORT OF CREATIVITY

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KEYWORDS
Virtual Reality, Creativity, Idea Generation, Hardware Infrastructure, Software Architecture

ABSTRACT

The contribution includes the software architecture and the hardware infrastructure of a Virtual Reality (VR)-based tool supporting creativity and idea generation. The concept was developed based on specific requirements the fields of distributed working teams, VR technology and creativity.

INTRODUCTION

Creativity is an important ability to drive innovation. Specific creativity techniques are used for fostering creativity and for generating new ideas. Conventional creativity techniques are often most suitable for local teams. In the context of distributed working teams the usage of conventional creativity techniques carries the risk of high monetary efforts and stress for employees. Conventional information and communication technologies (ICT) such as video conferencing do not fulfill the requirements to collaborate intuitively and creatively.
The implementation of Virtual Reality (VR) technology provides project teams the possibility to enhance creativity and to push idea generation in distributed working teams. The paper at hand is motivated by this potential. It describes the concept of a VR-based creativity technique including an adapted creativity process and the design of a supporting VR-based tool. The contribution focuses on a) suitable hardware infrastructure and b) necessary software architecture to include aspects being fundamental for working creatively in distributed teams with VR.

STATE OF THE ART

The state of the art being relevant for the support of creativity by VR consists of the fields creativity and ICT. In the following sections the foundations for the design of the VR-based tool are presented.

Creativity

Guilford defined creativity by the sequence of divergent and convergent thinking. Divergent thinking describes the generation of suitable ideas by opening an idea space. The result is a high range of generated ideas. Convergent thinking describes the process of identifying the most suitable idea in the range of generated ideas. (Guilford 1950)
Amabile developed in her research a creativity process for individual and small groups. The process is structured from task presentation to outcome assessment. According to Amabile, three different human specific aspects are important to support the process: intrinsic motivation, skills in the task domain and skills in creative thinking. (Amabile 1988)
Mumford described creativity as the “ability to create something new”. This characteristic is the basis for the development of innovative product ideas (Mumford 2003). Creativity techniques such as brainstorming or method 6-3-5 were developed to foster this ability.

ICT for creativity and idea generation

So called innovation community platforms are used for fostering the ability of creativity. Both Albers et al. and Maul investigated and developed community platforms for sharing and networking ideas in an organization (Albers et al. 2015, Maul 2015). Furthermore, Walter et al. developed the live lab concept “ProVIL” for the support of distributed teams in projects. This concept includes the integration of ICT in innovation processes (Walter et al. 2016).
The influence of virtual environments on creativity was investigated by few researchers. Bhagwatwar et al. investigated the idea generation process of humans in creativity primed virtual worlds (Bhagwatwar et al. 13). Alahuhta et al. defined eight factors being important for fostering creativity in virtual worlds. The contribution includes factors such as immersion, co-presence and multimodality (Alahuhta et al. 2014). On the basis of these investigations, Gräßler et al. investigated the influence of mobility and interaction in VR on user´s creativity (Gräßler et al. 2017). Additionally, a comparative study with conventional creativity techniques was carried out to investigate the performance of VR-supported creativity techniques by Gräßler and Taplick (2018).

ARCHITECTURE OF THE VR-BASED TOOL

Primary aim of the VR-based tool is the support for idea generation in a creativity technique. General requirements for the support of distributed working teams, creativity specific requirements and benefits of the VR technology have to be taken into account.

Specific Requirements of Distributed Working Teams

Virtual Reality technologies provide the possibility to communicate location independently with other users. To generate an intuitive way of **communication** user-friendly forms have to be implemented. Specific software scripts and devices have to be integrated in the VR-based tool.
The **network infrastructure** being used for the VR-based tool has to be prepared to enable communication. Additionally, the tool has to include **mobility** and **interaction** functionalities for an intuitive handling. Suitable devices have to be chosen and scripts have to be integrated in the software architecture for the usable implementation of the tool.
User acceptance and thus **usability** are influenced positively by taking some usability specific guidelines into account.

Creativity Specific Requirements

To develop a VR-based tool for the support of creativity and idea generation, several creativity specific requirements are important. One important point is the procedure of ideas from the generation to the documentation of the ideas.
The tool needs to have functionalities which support the **idea generation**, **modeling and improving of ideas** as well as corresponding **documentation**. The implementation of these functionalities have to be generated by the integration of specific software scripts.
Core requirement for supporting creativity and idea generation is the **creation of stimulation** by appropriate virtual contents (i.e., environments and embedded objects).

VR specific Benefits

Using VR technology for the support of creativity and idea generation provides potentials which have to be based on benefits of the technology. The first point is the possibility to **stimulate the visual sense** of users. In comparison to visual media such as pictures VR provides interactive visual content which can be regarded from different perspectives.
The stimulation of other senses such as auditory, olfactory or haptic stimulation is possible by **combining VR devices with other devices** such as haptic gloves or headphones. Another differentiating aspect from other visual media such as videos is the **high immersion** of users by the technology. Users feel involved in the virtual environment and are concentrated on the visual stimulation without being influenced visually by the real environment.
For generating visual stimulation by VR, **specific content** is needed which have to be implemented in a database with an interface for the VR-based tool.

Hardware Infrastructure

Hardware and software infrastructure have to be adapted for the support of distributed working teams and the implementation of creativity specific requirements.
The hardware infrastructure of the VR based tool for the support of creativity was designed, based on the model for VR hardware architecture of Dörner et al. (2013). Dörner et al. describe human machine interaction in VR systems by the division in input, human processing, output and other subsystems such as databases, network and world simulation. The signals of input devices are combined by sensor fusion for the world simulation which is influenced by sensory input.
The answer of the world simulation is displayed by sensory stimulation which is divided by the rendering for the suitable output devices. In the context of supporting creativity and idea generation the configuration of subsystems has to be adapted for this application.
Communication: Communication is one of the most important factors for distributed working teams. Communication is provided by the integration of Information and Communication Technology (ICT).

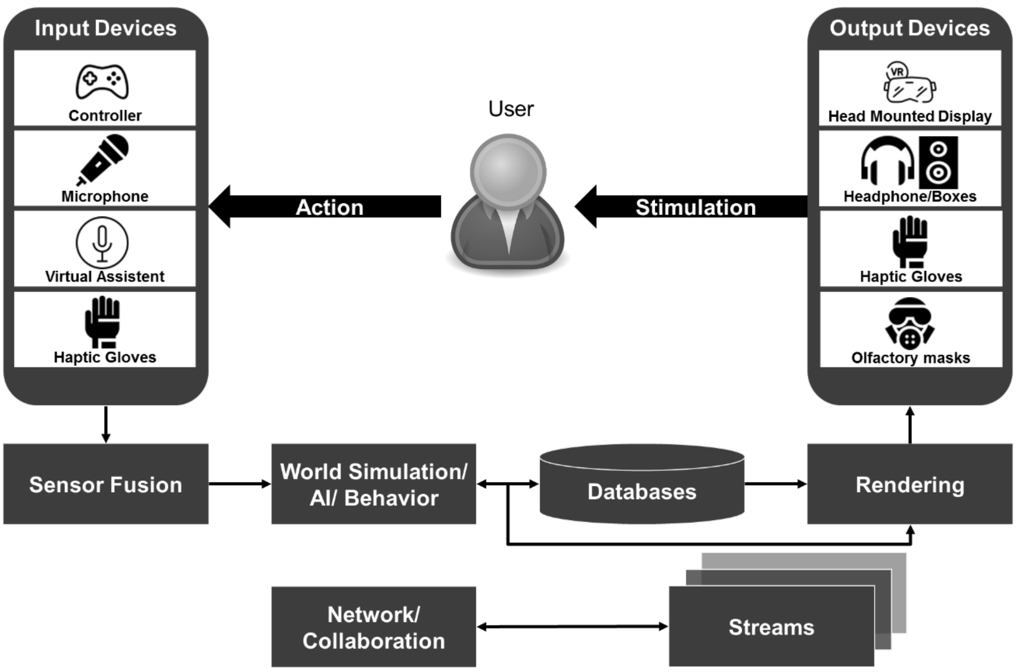

Figure 1: Hardware infrastructure of the VR-based tool (based on Dörner et al. 13)

For the implementation of intuitive communication in VR systems specific input and output devices have to be implemented.

For humans an intuitive way to exchange information is the auditory communication. For the communication with other users and the environment, users need input devices such as a microphone or virtual assistant which receives the auditory input of the user. For the receiving auditory information the system needs to have suitable output devices such as boxes or headphones.

Network infrastructure: The most important point for the configuration of the network infrastructure is the operation without failures. For the usage of the VR-based tool implemented in a creativity technique, the capacity of the network must include small groups which are interacting in creativity sessions. Servers and cloud solutions provide enough capacity to handle the size of participants in creativity sessions.

Mobility and interaction: The integration of mobility and interaction is important for the users of the VR-based tool to receive stimulation from different perspectives and to interact with the virtual environment. There are solutions for supporting mobility combining VR hardware with scripts directly accessing hardware interfaces. One example is a controller of a High-end Head Mounted Display (HMD) being an input device for the user. In combination with a teleportation script which can be activated with the controller, the user can change the position in virtual environments. Additionally, the controller can be used for interactions with 3D-models. Touching 3D-models with the controller leads to reactions if the 3D-model includes scripts for interactions such as radial or rotation movements. Another possibility to enhance the intuitive interaction with other users and the virtual environments is the implementation of haptic stimulation. Haptic gloves with force feedback support the immersion by feeling the resistance of objects by interacting with them.

Stimulate the visual sense: VR technology provides the possibility to support humans by stimulating the visual sense. For a location independent usage of the VR-based tool for supporting creativity and idea generation, the implementation of a handy device is required.

Stationary VR systems such as CAVE or Powerwall are not suitable for the use in this context. High-end HMDs fulfill the requirements for using it location independently. The HMDs are implemented as output devices for the VR-based tool.

Combining VR with other devices: HMDs are the most important output devices for the stimulation of the visual sense. To increase the immersion of virtual environments the combination with other output devices focusing other human senses such as olfactory, haptic and auditory sense is necessary. Additionally, the stimulation of several senses multi dimensional experience is necessary for being able to lead to associations being relevant for idea generation. Possible devices for the sensual stimulation are olfactory masks which includes different fragrances. They can be activated by interactions with virtual environments. For haptic stimulation the force feedback of haptic gloves provides touching objects. The combination of visual and auditory stimulation is the most used variant in virtual environments. The stimulation of the auditory sense requires conventional hardware such as headphones or boxes. Implementing auditory systems increasing the spatial sound lead to a higher immersion for users.

High immersion: Immersion is defined as the integration of a user in virtual environments. To achieve the aim of generating high immersion, the virtual environment cannot differ from the real world of the user. This is possible when all senses of the user can be deceived through hardware and software. For an approximation of perfect immersion, implemented hardware should enable to stimulate all human senses. Regarding the state of the art, the stimulation of the visual sense by virtual reality devices and the stimulation of the auditory sense by boxes and headphones are possible without high economic means. Devices for the stimulation of other senses are partly available (haptic gloves, olfactory masks, …), but do not fulfill the high requirements of imitating the realistic experiences. This point leads to the implementation of devices for visual and auditory stimulation. By reaching a higher maturity grade, devices focusing other senses should be implemented.

Software Architecture

Several scripts have to be implemented for taking all aspects into account. These scripts are divided in the following categorized classes: Environment configurator, Modeling, Collaboration, Documentation and content. In this section, requirements being relevant for distributed working teams, creativity and VR technology benefits are enlisted and detailed. Additionally, scripts which are part of the implementation of these aspects are described.

Idea generation: Handling of ideas from the generation to the documentation are important for the complete process of a creativity technique. The idea generation is a phase of divergent thinking. For the generation of a high number of ideas, intuitive creativity techniques such as Brainstorming or Method 6-3-5 are suitable. Other creativity techniques such as “Stimulus Image Technique” include media (pictures) to stimulate participants. By the stimulation of media the participants identify new ideas by associations of the stimulation. Stimulations have to vary to create a high number of ideas. In the context of the VR-based tool for the support of creativity and idea generation, virtual environments are used as stimulation for participants (Virtual creative environment). Different virtual creative environments have to be developed to vary the stimulation. For the support of the development, an environment configurator consisting of a range of scripts is implemented in the VR-based tool. The scripts of the environment configurator fulfill specific functionalities being important to create environments in VR. The most important script in this context is “Add 3D-model”. The implementation of this script allows the user to add 3D-models of a database with different topics and complexity (range of polygons of the 3D-model). The 3D-models differ from simple objects (cube, sphere,…) to complex 3D-models such as a polygon modeled milling machine consisting of parents and child parts. The changing of 3D-models stands in a direct context to the addition of 3D-models. The script “Transform 3D-model” allows the user to change the properties of 3D-models. The modification includes the scaling and rotation in x-, y- and z- axis.

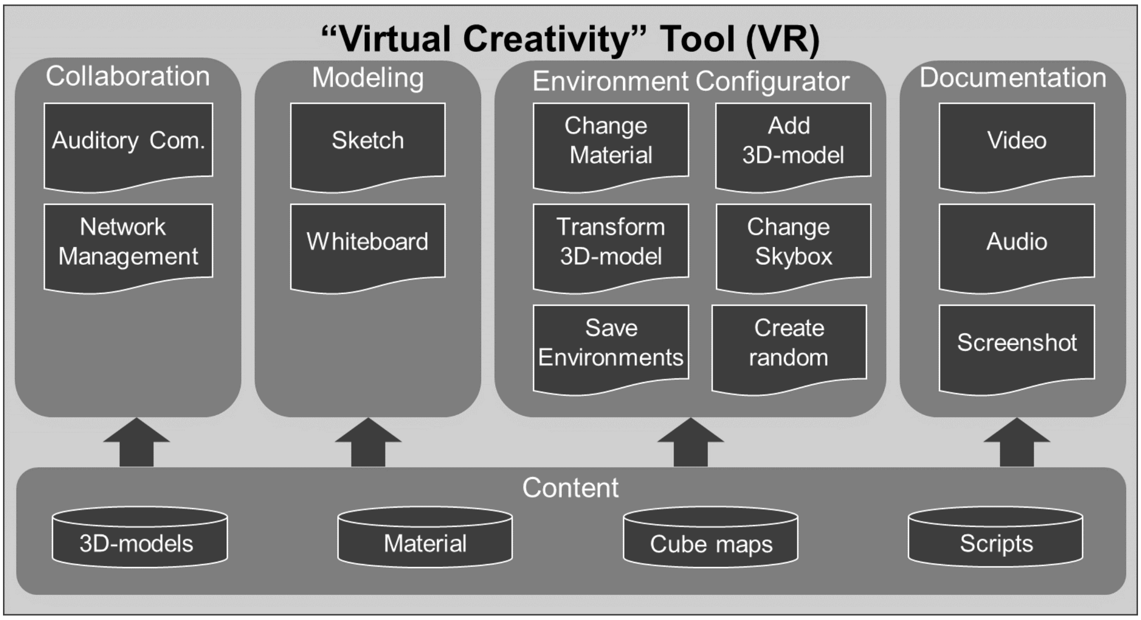

Figure 2: Software architecture of the VR-based tool to support creativity and idea generation

Thus, the enlargement, reduction and distortion of a 3D model is possible. Another funcitionality is the changing of materials. A material describes the surface composition of 3D models. It can differ by the implementation of colors, textures and light models. The script "Change Material" allows to change the material of every 3D model in the virtual creative environment. By changing the material, unusual designs of 3D models can be generated such as a milling machine with a wood casing. Another functionality of the environment configurator is changing of the skybox (i.e., the horizon of the virtual environment). Cube maps (consisting of eight different perspective images) are the content being necessary for the change of the skybox. Thus, users can implement the horizontal view of a city or nature environment. For the usage of the developed virtual creative environments in several creativity sessions, a functionality to save environments is required. The implemented script "Save Environments" fulfills this requirement and includes saving of 3D models, chosen materials, cube maps and property adaptions of 3D models (materials, scale and rotation). The environment configurator provides a "random" functionality being important for time critical sessions. If it is impossible to create virtual creative environments manually, the script "Create random" can be used to create a random creative environment by chosen a required number of 3D-models and enabling or disabling rotation and scaling.

Modeling and improving ideas: After the generation of an idea, it has to be modeled and improved. Several reasons such as creating a shared mental model by a complete team or the creation of a base for following ideas are given for the implementation of functionalities supporting idea modeling and improving. The modeling class is implemented for the fulfillment of these tasks. The functionalities are focused on the visual description of the ideas. The visualization of ideas helps users to describe ideas more in detail. This leads to a better understanding of other group members. Based on the better understanding, members can improve the idea or use it to generate other ideas. One functionality to support the visualization is a "Sketch" script. Spheres are selected as 3D primitives to generate sketches.

Pushing of a controller button adds a new sphere. Keeping the button pressed and moving the controller creates a line of spheres. Additionally, color and diameter of the spheres can be changed in the menu. The implementation of this functionality allows sketching of simple three-dimensional shapes. The script "Whiteboard" is implemented for the creation of two-dimensional sketches. Activating this functionality in virtual creative environments leads to the appearance of a virtual whiteboard with different colored pens. Users of the VR-based tool have the possibility to sketch their ideas on the virtual whiteboard.

Documenting ideas: The final step of handling ideas in a creativity technique is the documentation of ideas. Different types of documentation functions are required for using visualizations to model ideas and mention ideas in auditory form. The implementation of the class "documentation" provides the availability of different forms. The script "Video" includes the functionality to record aspects of the environment. Thus, the functionality can be used to record combined 3D models being an idea for a specific task or a sketch with the three-dimensional sketching functionality. Another form of visual documentation provides the "Screenshot" script. In comparison to the video functionality the documented content (images) is static, but need less capacitance. Another possibility for documenting ideas is the implementation of audio specific documentation form. The implementation of a virtual assistant or a speech recognition functionality makes this documentation form possible.

Specific content: For the design and variation of virtual creative environments specific content must be available. For the implementation of such contents, a database has to be used including 3D models, materials, cube maps and scripts. The content has to be divided in topic specific categories. Simple 3D models such as spheres or cubes are separated from complex 3D models with a technical topic such as production.

Communication: The use of the VR-based tool for distributed working teams requires the support of communication between team members. The implementation of hardware for input and output is one step being necessary to guarantee the communication ability in the tool. The other step is the implementation of the class collaboration. Standardized scripts are available to generate a voice over IP connection.
Usability: For the acceptance by users, usability is essential. Rules for the design of interfaces and menus are documented in guidelines (DIN EN ISO 14915, VDI/VDE 3850). For the design of a VR tool there have to be taken additional characteristics into account to generate a suitable usability:

- Viewpoint in VR applications
- Properties of the content
- User interface

The first aspect "Viewpoint in VR applications" is about characteristics such as the movement of the camera should only be manipulated by the user. The characteristics include recommendations being necessary to prevent motion sickness (Oman 1988). The second point "Properties of the content" deals with the position and presentation of important content. For example, the light intensity should not change. Another recommendation includes the ideal position of important content for different VR devices for an optimal view. The third point "User interface" consists of recommendations for user experience such as the implementation of learning support or a feedback function.

Usage of the VR tool in a creativity technique

The developed VR-based tool has to be implemented consequently in different phases of a creativity technique. It supports the enlargement of the idea space. The environment configurator is used in a preparation phase to design virtual creative environments for the idea generation. The different scripts enable the usage of functionalities to generate these environments. The accessibility of content in the prepared database is fundamental for the generation of virtual creative environments. In the following phase of idea generation the VR-based tool is used to load the generated virtual creative environments. Users experience the environments and generate ideas on the basis of their task. For the communication with other users collaboration tools are implemented. First ideas can be modeled and improved by the usage of modeling tools. Finally, the improved ideas can be collected by documentation tools.
On the basis of these sequential phases of the creativity process the most suitable ideas are identified within the set of generated ideas.

CONCLUSION AND OUTLOOK

For the support of creativity and idea generation by VR technology, a suitable hardware infrastructure and software architecture have to be designed. The hardware infrastructure includes input and output devices supporting the receiving stimulation and interaction with virtual environments. The software architecture includes scripts being categorized in environment configurator, modeling, collaboration, documentation and content. The scripts fulfill different functionalities such as adding 3D-models in the environment configurator.

The next research step is the validation of the creativity technique "Stimulus Environment Method" in an industrial project. The creativity technique will support a distributed working team to generate ideas.

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BIOGRAPHIES

Prof. Dr.-Ing. Iris Graessler studied mechanical engineering and graduated in 1999 as a PhD (Dr.-Ing.) at Aachen University of Technology (RWTH Aachen), Germany. In 2003 she qualified as a university lecturer (Habilitation) at RWTH Aachen. For 14 years she has been working at Robert Bosch GmbH in several management functions in the field of Innovation Management, Product Engineering, Lean Manufacturing and Continuous Improvement Process. Since 2013 she is in charge of the Chair for Product Creation at the Heinz Nixdorf Institute at Paderborn University.

Patrick Taplick was born in Salzkotten, Germany and went to Paderborn University where he studied industrial engineering and obtained his master degree in 2014. After the study he worked for the Chair for Product Creation with the subject Digital and Virtual Engineering ever since.

IMPLEMENTATION OF AR BASED ACCENTED VISUALIZATION IN INDUSTRIAL INTERACTIVE USER GUIDE

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KEYWORDS

Augmented Reality, Smart Manufacturing, Industry 4.0, Ontology, Decision-making Support

ABSTRACT

There are presented the results of AR technologies implementation in practice for manual operation control. There are discussed some aspects of industrial application of image data processing, analysis, virtualization and presentation based on Augmented Reality and the Internet of Things. Main attention is given to the usability of interactive user interfaces and knowledge based data processing to improve the quality of intelligent technologies efficient use in digital industry applications. The paper develops the ideas of accentuated visualization based on adaptive construction and virtual consideration of the content of the current real scene in the field of view of a person, as well as the viewer's experience that contains perceptions, points of view and expected behavior. The proposed solution is used to identify gaps and failures of operator in real time, predict possible operating mistakes and suggest better procedures based on comparing the sequence of actions to an experience of highly qualified operators.

INTRODUCTION

One of the most perspective areas of AR implementation in practice is cyber-physical systems of modern industrial enterprises. Digitalization in this area prescribes broad use of Augmented Reality and the Internet of Things and is generalized under the concept of Industry 4.0. The technology is based on monitoring production processes, supplementing them with specifically generated virtual entities and providing contextual and decentralized decision making support. These features require implementation of innovative user interfaces suitable for image data processing, analysis, virtualization and presentation.

Technical challenges of AR implementation are concerned with better objects identification using various image recognition algorithms and adaptive technologies of accented visualization. Some issues of AR practical application were discussed in (Ivaschenko 2017, 2018) giving an illustration for a robot design kits. Getting closer to real deployment of AR in automobile industry there were achieved new results in 2018 described below in this paper.

STATE OF THE ART

The concept of Industry 4.0 (Lasi 2014, Kagermann 2013) describes a solution vision based on implementation of modern IT technologies to develop cyber-physical systems for smart factories. Based on existing and rich experience of manufacturing automation it picks out the most efficient technologies that can be applied in practice to improve the efficiency of the general supply chain. By means of monitoring and application of intelligent technologies for predictions and decision-making support Industry 4.0 concentrates on providing maximum controllability of business and production processes. Under these conditions the role of human decision-makers remains still critical, which makes it important to provide usable and useful user interfaces.

Basic technologies of Industry 4.0 include Big Data analytics and the Internet of Things (Bessis 2014) that provide early detection of defects and production failures, thus enabling their prevention and increasing productivity, quality, and agility. One of the challenging areas of their implementation is manual operation control that requires identification of assembly units and details at the required stages of production process and tracking of operations over them with the corresponding decision-making support.

Intelligent systems for manual operation control are close in use cases and functionality to interactive user guides that also implement AR for decision making support at certain stages of operating processes. Most modern AR technologies (Navab 2004, Krevelen 2007, Singh 2013) provide powerful and adaptive user interfaces. Various AR devices (goggles, head mounted displays or widely spread tablets) provide overlaid information additive or masking the real environment that can be informative for the users. AR technology allows developing interactive and context-dependent user interfaces that provide the possibilities of computer vision and object recognition in real time. These features make AR a powerful tool of Industry 4.0 implementation in practice that can considerably improve the capabilities of computer-human interfaces.

Contextual data visualization (Holzinger 2014, 2016) is provided to combine several data sets to analyze multiple layers of a biological system at once. The system should interlink all related data sets (e.g., images, text, measured values, scans) and offer visual analytics to support experts. This approach is widely used for medical data processing, but can be easily disseminated for a cyber-physical system. This approach supports the idea of maximum effective visualization of complex data for professionals instead of automatic decision-making. In addition to this it is proposed to involve the decision maker into the process of data processing and visualization by means of continuous interacting with the system, which helps optimizing the learning behavior of both humans and algorithms.

Applying AR to Industry 4.0 makes it possible for users to be trained for those tasks, and actively assisted during their performance, without ever needing to refer to separate paper or electronic technical orders (Friedrich 2003, Ke 2005). Incorporating instruction and assistance directly within the task domain, and directly referencing the equipment at which the user is looking, could eliminate the current need for personnel to continually switch their focus of attention between the task and its separate documentation. As a result the user is able to receive visual aids for operating using user interfaces that support each task naturally without distracting.

SOLUTION ARCHITECTURE

Based on the methods of contextual data visualization and interactive computer-human interaction there was developed a concept of accented visualization. System architecture is presented in Fig. 1.

The concept is based on formalization of <focus, context, and overlay context> for each actor in Operator Ontology. Context is a set of concepts that describe the current situation and background that determines the decision. Focus is a concrete object processed at a certain moment. Overlay context includes virtual entities (textual items, marks or highlights) that attract user's attention to the required scene objects when needed. Such fragmentation allows introducing a control loop, where the correct focus is stimulated according to the context in real time.

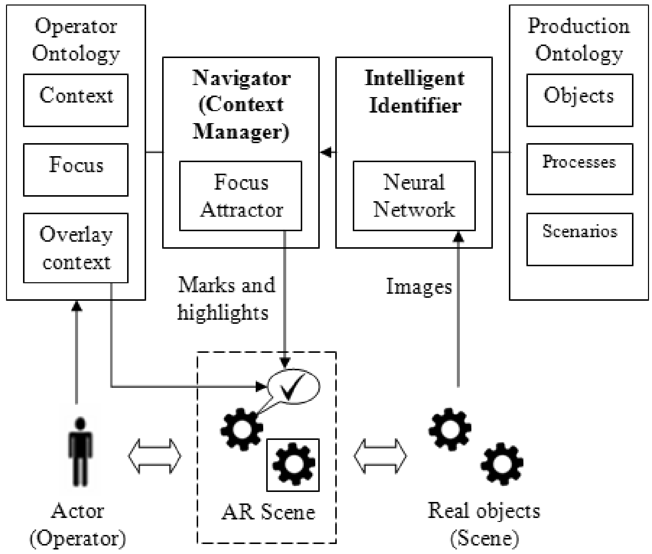


Figure 1: Accented visualization solution for intelligent control of manual operations

Navigator module (context manager) implements user's focus coordination is based on intelligent analysis of production processes. User's focus is captured in the form of event chains and compared with typical scenarios. The system tracks user attention and adapts additional data of overlay context introduced to virtual scene according to the current need.

Identifier module implements intelligent pattern recognition using e.g. neural networks. It is a basic component of the whole solution and provides identification of all the objects in view and Navigator data support.

Production Ontology is a knowledge base that contains the description of production processes, technologies and necessary equipment as well as critical features or characteristics of each object. Rules of their processing are taken from production processes and coordinated with other scene objects and steps of operating scenarios. Eye tracking software and hardware is introduced to identify possible gaps in viewer's perception, if no required attention is given to certain scene objects at necessary times.

IMPLEMENTATION

The proposed approach was implemented in a specialized intelligent system for industrial manual operation control. Such a system implements the ideas of Industry 4.0 for smart manufacturing by introduction of cyber-physical decision-making support.

The following functionality is currently available:
- scene object identification based on image analysis;
- complex devices analysis including components identification by partial view and assemble tips generating;
- contextual description of the object in view;
- search and highlighting of the object required;

- user attention identification and contextual add-ons generating according to the principles of accented visualization;
- operating scenario processing, tracking, and control.

One of a vehicle truck engine unit (turbo-compressor) was taken as an example. Objects identification is illustrated by Fig. 2. The required object is contextually highlighted according to the production process (see Fig. 3).

There are several options of the system deployment at the industrial working place. AR scene can be presented on a tablet or AR goggles (e.g. Epson Moverio). However there are still problems with using AR goggles in practice due to a necessity to personalize them and provide continuous usability and comfort.

In this respect there were explore other possible ways of the system deployment using cheap and widespread equipment. Possible options are given in Fig. 4 – 5). A number of video cameras are used to track operations according to production process and identify the objects to be operated in real scene.

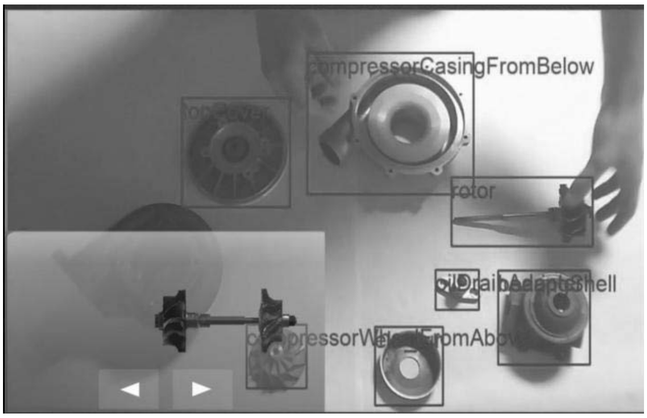


Figure 2: Intelligent manual operations' control. Objects identification

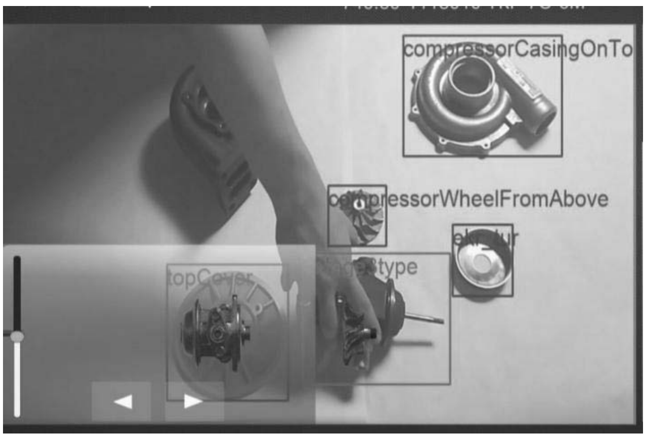


Figure 3: Intelligent manual operations' control. Relevant object identified and highlighted

Figure 4: Intelligent manual operations' control. Working place

Figure 5: Intelligent manual operations' control. Head mounted device

Intelligent software provides image recognition of the objects and their matching with a corresponding description in a knowledge base. Video panels or AR goggles are used to present the corresponding contextual information to an operator.

One can see that no extra limitations for the working place and lighting (like e.g. green background) are required. Simple web cameras can be used to track and capture the objects: the quality of video is good enough for the most op-to-date models. Still it is recommended to introduce minimum two cameras to reduce the defects of lighting caused by occultation and blur. The quality of lighting turns out to be not so critical, which makes it beneficial being deployed at real enterprises. Considerable lighting changes require additional calibration.

The overall solution is used to identify gaps and failures of operator in real time, predict possible operating mistakes and suggest better procedures based on comparing the sequence of actions to an experience of highly qualified operators.

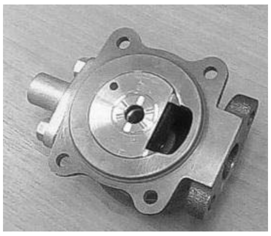
APPLICATION ASPECTS

The problem of AR implementation was concerned with stable and reliable recognition and identification of the objects in view. For example, one of the main challenges of AR user guides is a necessity to identify the object that is required at the current moment, attract the user's attention and give complete and comprehensive annotation. To provide such features the technology should be capable of processing substantial number of images in real time.

Intelligent image recognition and objects identification in practice is usually performed using standard neural networks. There were considered several alternative libraries, including Tensorflow (which is the most fast), Keras, Theano (no longer supported by the developers) and Deeplearning4j (supports Java). Thesorflow was chosen for implementation, in addition to high productivity it is distributed under the open license Apache 2.0, provides access from Python, C++, Java, Haskell, Go, Swift API, supports Linux, Windows, macOS, iOS, Android, supports Google and cloud computing and gains high popularity among the developers.

Among the possible neural network topologies (AlexNet, VGG16, GoogLeNet/Inception, etc.) there was chosen ResNet-50, a Residual Network powered by Microsoft. ResNet-50 is a convolution neural network that is trained on more than a million images from the ImageNet database. It contains is 50 layers deep with direct links between the neurons located by one level.

Despite the variety of shapes of the objects in practice most of industrial components look similar. In addition to this the solution should be capable of identification of overlapped details with the lack of required visual data. For example, the assembly unit of two details is combined of a bearing case and adapter (see Fig 6). Adapter does not add much identity (adapter produces 10 – 15 % of the overall picture space), so the two pictures of bearing case and assembly unit look close to each other. Standard intelligent identification algorithm gets them mixed up.



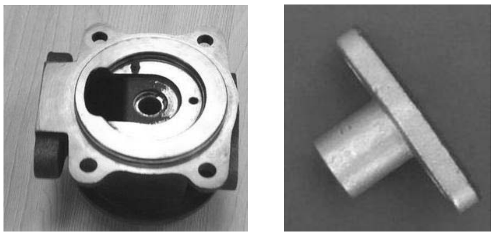


Figure 6: Assembly unit to be identified and its details: bearing case and adapter

The problems like this can be solved using the proposed concept of accented visualization. According to this approach intelligent identification algorithm is wrapped by knowledge driven logic that coordinates its target on the basis of correlation between the user's focus and context.

To provide the context driven decision-making support there was built a table of objects with possible distribution and probability of occurrence is view. On the basis of this table there is developed a decision-making tree that determines the sequence of stages and requirements for a details' list to be presented in view for each stage. Therefore the current stage determines the priority of objects identification.

For the given above example there can be specified a rule that in case for a collision of bearing case/assembly there is identified an adapter in view separate to an analyzed object with a probability of 0,7 then the object is identified as a bearing case. This logic corresponds to 5S methodology of workplace organization that requires no foreign objects exterior objects to appear in scene.

Implementation results for a real case of assembly units and details identification of a vehicle truck engine unit (turbo-compressor) considering the requirements of production process are given in Fig. 7. The functions represent the dependency of a number of faults of identification step.

The faults were calculated in the following way. There was recorded the screen of identification procedure. The resulting video (duration time 9,13 min) was analyzed by an expert. Each 10^{th} screenshot was taken for analysis and the object identified by the system was compared to the object required for identification according to the production process. The total amount of steps (1271) is presented in the figure. Each step corresponds to a certain video shot scene.

There were taken two cases of identification: considering the context and without it. The first case that considers no context and implements neural network only for intelligent identification of objects in view is illustrated by the upper function. Total amount of faults is 802, which takes the range of 63.1%. The second case considers the context and results with 86 faults which takes 6.8% of all steps.

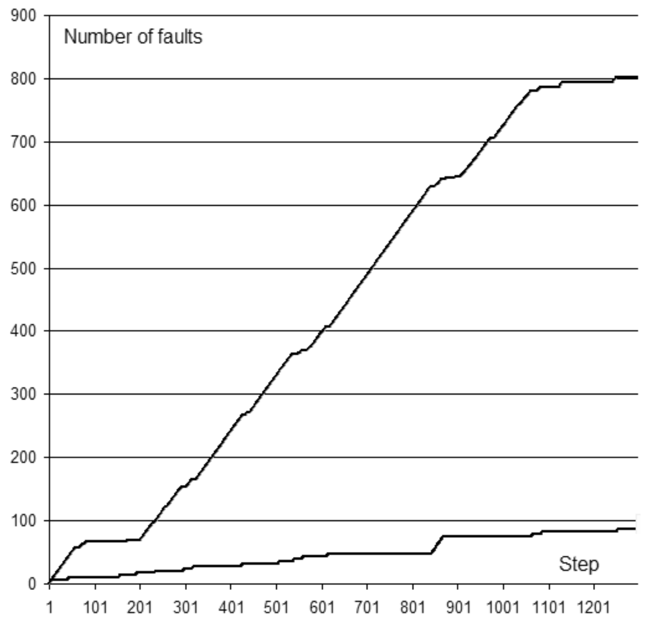


Figure 7: Accumulation of identification faults (errors): considering the context (lower graph) and no context (upper graph)

This example shows that the recognition rate of objects successful identification using accented visualization if 93,2% comparing to standard technology that presents 36,9%.

DISCUSSION

Implementation of accented visualization approach that considers that combination of focus and context can be presented in the form of two layers: Identifier directly for intelligent pattern recognition and Navigator acting as a wrapper for Identifier. Navigator can be used for pre-processing of input data reducing obvious mistakes and interference. It can either be used for post-processing of identification results to improve their interpretation as a part of decision-making support.

Considering the context at the second layer can provide better targeting the intelligent algorithm or choose the most appropriate algorithm from a certain list. From this perspective it can be implemented using the formal logic predefined by an expert (like in the given above example). There can be proposed a special visual tool to describe this logic in the form of decision-making tree or semantic network as a part of ontology. This tool can get special user interface for a number of experts and be later used for the system configuration.

Navigator can also implement its own neural network as an alternative that is trained in a different way than a first layer and therefore becomes capable producing additional logic of data pro-processing and interpreting. Input of this layer in this case will take the distribution of objects identification probabilities from the first layer and determine the context in the form of i.e. stage of the process.

Possible issues of implementation of the proposed approach contain high dependency on the first layer that remains the main source of information and basic identification tool and complexity of decision-making trees or semantic networks in the second layer in case of processing multiple objects, stages, cases and processes. Nevertheless this approach remains effective for use of intelligent technologies in practice and allows increasing their adequacy and sufficiency for industrial applications.

The described intelligent system for manual operation control with the provided identification quality has won a specialized contest organized by KAMAZ, Skolkovo Foundation and a Foundation for Advanced Studies in a nomination of the best industrial solution in August 2018.

CONCLUSION

The results of a presented research help solving technical problems of AR implementation in real applications that is still critical in industry. This solution is proposed to be used in practice used to identify gaps and failures of operator in real time, predict possible operating mistakes and suggest better procedures based on comparing the sequence of actions to an experience of highly qualified operators.

As a result there can be achieved better production process monitoring and control using intelligent image recognition algorithms and adaptive technologies of accented visualization.

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DESIGNER SHOPPING AND FUTURE HEALTH CARE ENVIRONMENTS

INTELLIGENCE IN RETAIL: THE DECISION-MAKING BEHIND CLICK-AND-COLLECT

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KEYWORDS
Click and Collect, E-Commerce, Optimisation, Profitability.

ABSTRACT

Among many web-to-store solutions, we optimize a click-and-collect service, a shopping facility whereby a customer can order products online from a brand's website and collect them from nearby stores. Given a click-and-collect order consisting of a set of products, the problem we present in this paper is to simultaneously select a list of stores from which the customer chooses its preferred pickup point and optimize the profitability. The global profitability comes from several independent factors. A profitable idea is to use the in-store stocks to satisfy all or part of the click-and-collect orders: it avoids transportation costs, it reduces the delivery time, it helps control (speed-up, speed-down) the in-store stocks. A sequence of mathematical programming problems is solved in order to optimize a stochastic criterion that approximates the global profitability. We evaluate our proposed technique with both real and simulated data. The real data come from a large UK retailer now equipped with the click-and-collect tools from devatics.com.

INTRODUCTION AND MOTIVATION

We focus on one of the most prominent topics related to IT in retail: omnichannel retailing. Brands recently moved from the multichannel to the omnichannel concepts (Verhoef et al 2015): while the multichannel implies a clear separation between the physical and online stores, the omnichannel customers move seamlessly between the online, mobile devices, and physical store, all within a unified customer experience. Mobile and social media channels also expand "traditional" online and physical channels. Retailers remove barriers within the channels and now provide and promote cross-channel services such as "click and collect", "order in-store", "order online, return to store", "ship-from-store" and other combinations of retail functionalities. It is widely admitted that AI will play a prominent role in the digital transformation of the retail moving from bricks to clicks. In this work, we show that there is room for optimizing the profitability of the well-known "click and collect" service: the ability to order and return or exchange goods in-store, ordering while in-store, using own mobile device or self-service technology provided by the retailer. Nowadays, large retailers combine ordering by internet with picking up goods at their stores since customers have a much wider choice of products to choose from and have the certainty that the products are available when they pick them up. Click and collect is very popular with brands (often low-value) which do not offer free shipping or free shipping is only available above a significant basket value. For these brands, click and collect can represent up to 60% of their ecommerce turnover. Express click and collect is expected to be increasingly popular in the near future, while Amazon is educating consumers to be more demanding on time, expect swifter delivery options, in particular local express deliveries.

Usually, the customers have a large choice of delivery options and, in this field, there are several types of pickup points (Morganti 2014). In this article we are only interested in brand's stores as pickup points since we want to assess if using the in-store stocks could improve the profitability of the click-and-collect solutions. Since the click-and-collect service is relatively new and relatively mechanical in appearance, to the best of our knowledge there is no previous research conducted on methods for optimizing the click-and-collect orders management. Masel, and Mesa only investigated the picking process (Masel 2018) while most of the research is focused on the customer analysis and the purchasing behavior of the click-and-collect customers (Huyghe et al 2017) given a distribution of pickup points (Morganti 2014).

In Figure 1, we illustrate the last step of a click-and-collect order from an important UK fashion retailer we are working with. The customer has filled his shopping cart (£49.00), has chosen his delivery method among several options (standard/express/Saturday delivery, click-and-collect, express click-and-collect), has given his contact details (including his postcode) and can then choose a pickup point from nearby stores of the brand. The key idea is to simultaneously select a list of stores from which the customer chooses its preferred delivery point and optimize the profitability. The global profitability comes from several independent factors. A profitable idea is to use the in-store stocks to satisfy all or part of the click-and-collect orders: it avoids transportation costs, it reduces the delivery time, it helps control (speed-up, speed-down) the in-store stocks. With large retailers and large network of stores, we show that it is possible to strategically select the proposed pickup stores while saving money, reducing delay and limiting transportation (energy use). In the figure we show that 9 optimal stores are automatically selected for the considered order since there are simultaneously close to the customer (see also his/her postcode) and because they are optimizing a stochastic performance criterion. Of course, in order to improve the quality of experience (QoE), the customer is only offered stores close to him systematically including, if any, stores in which he has already bought products or withdrawn online purchases. The optimization is only done within this high QoE perimeter.

Figure 1. Store Selection/Locator from a Postcode and the Profitability Optimization

DECISION-TAKING PROBLEMS BEHIND CLICK-AND-COLLECT

Given a click-and-collect order consisting of a set of products, the problem we present in this paper is to simultaneously (i) select a list of stores from which the customer chooses its preferred delivery point and (ii) optimize the click-and-collect profitability. The global profitability comes from several independent factors. A first profitable idea is to use the in-store stock to satisfy all or part of the click-and-collect order. Assuming that the entire order is already available in the store selected by the customer, there is no delay and no transportation cost from the central warehouse (DC) to the delivery point (i.e. the selected store): the customer clicks and could immediately go and collect his order. However, if the order reduces the stock of the selected store too much, in-store sales can be lost before replenishment, which is overall negative for the brand. In order to compromise between cost savings, fast delivery experience and potential negative impact on the in-store sales, each time the in-store stock is used to satisfy a click-and-collect order, we estimate a cost (resp. a reward) based on the probability of losing a sale (resp. reducing an overfilled stock). To do so, a demand model must be available to predict not only the in-store sales but also the in-store stock-outs or overfilled stocks. One must notice that it is a strong approximation to say that using the in-store stocks leads to immediate delivery. The optimization and cost of the picking process (Masel and Mesa 2018) could also be considered.

We introduce the following notations. Let D = {1,..., n} be all the products requested in a click-and-collect order. For each product j ∈ D, we note by dj the quantity requested for the considered order. These variables uniquely define an order o=(d1, … dj, … dn). The set of stores is denoted S = {1, ... S} and for each store I ∈ S, Pi ⊆ D is the set of all the products available in store i. As the stocks of the stores are known, we denote $xij \leq dj$ the unknown quantity of products j that is taken directly from the stock of store I to satisfy the order o if the i-th store is selected for delivery. The xij are decisional variables gathered into a matrix x whose i-th row xi describes the assignment for the i-th store. We assume without loss of generality that the remaining dj-xij quantity will be served by the DC with a predefined transportation cost. Our objective is twofold: (i) selecting a good subset of stores to be proposed as delivery points and (ii) optimizing the expected profitability if in-store stocks are used to reduce transportation costs and control stock levels. We note y=(y1, ..., yi, ... yS) the binary vector indicating which stores are selected. We note p(i|y) the conditional probability that the customer would choose the i-th store for collecting his/her order given the store selection y. The overall profitability Po(y,x) of an order o with the store selection y and the product assignment x is then the expected gain:

$$P_o(y,x) = \sum_{i=1}^{S} p(i|y)Ri(o,x_i)$$

with the Ri(o,xi) the non-negative reward coming from the selection of the i-th store for the delivery of o given the optimized use xi of in-store stocks. We basically aim at maximizing Po for each order o while determining the best subset y of nearby stores and the optimal use of in-store stocks x.

$$(y^*,x^*) = \underset{y,x}{\mathrm{argmax}}\, P_o(y,x)$$

We also constrain the search since we want to offer and display at least $\sum_{i=1}^{S} y_i \geq S_{min}$ stores in the click-and-collect store locator (see also Figure 1 where S_{min} is 6, 6 stores are displayed, and $\sum_{i=1}^{S} y_i = 9$, 3 other store locations are also possible).

The choice of $p(i|y)$ modelling can be adjusted depending on the considered vertical market (e.g. shopping patterns in grocery and fashion are different). A simple choice is based on the distribution of distances between the customer postcode and the pickup store locations (given y). We will see in the next section that we also preserve the quality of experience by forcing a high probability $p(io|y)$ if the customer is registered and used to buy products and/or pick up online orders in the io-th store!

We can then define the non-negative reward coming from the selection of the i-th store for the delivery of o by first solving a linear programming problem:

$$PLi \begin{cases} Max \quad R^{PL}(o,x_i) = \sum_{j=1}^{n} x_{ij} \quad r_{ij} \\ \quad x_{ij} \geq 0 \quad \forall j \in 1..n \\ \quad x_{ij} \leq S_{ij} \leq d_j \quad \forall j \end{cases}$$

where rij models the reward (or cost if negative) if we extract a product j from the available stock S_{ij} in store i. Many models based on sales forecasting can be injected here. Intuitively, we just need a monotonically increasing function of the stock Sij to model the expected behavior of rij. The optimization problem Pli being solved (we have then $x_i^* = (\dots x_{ij}^* \dots \forall j$)), we just have to introduce a transport penalty term Ci if the entire order is not handled by the i-th store. If $max\{0, \dots, sgn(d_j - x_{ij}^*), \dots\}$ is greater than 0, it means that a part of the order o will be handled by the DC leading to a flat cost (negative reward $C_i \leq 0$).

$$Ri(o, x_i^*) = R^{PL}(o, x_i^*) + C_i \max_j\{0, \dots, sgn(d_j - x_{ij}^*), \dots\}$$

The penalty term is typically a mix of delay and transportation cost (usually 4-6 pounds/euros) to be estimated with each brand and carrier operator.

RESOLUTION TECHNIQUE AND EXPERIMENTS

We can now describe the metaheuristic we use for optimizing the profitability of each order o. This is a heuristic due to the stochastic sampling we use and the stochastic criterion we maximize. An exhaustive search is not feasible (note that an equivalence with covering problems leads to NP completeness). The stochastic sampling of the search space is done in the first three steps (Step 1-3). A sequence of mathematical programming problems is then solved (Step 4-7) in order to optimize the stochastic criterion (P_o score) that approximates the global profitability.

The algorithm we propose requires to be integrated with the company's information system: both the Stock Management System (SMS) and the Customer-relationship management (CRM) are used. A smart integration should minimize the invasiveness of this intelligent component which is another aspect of this applied research.

We evaluated our proposed technique with simulated data in 2014 when we started investigating this problem. We now have real data to work with. The real data comes from a large UK retailer equipped with the click-and-collect tools from Devatics.com. In this article we seed our simulators with real data and normalize all the scores/costs/rewards with the AOV Average Order Value (£116) estimated from a real stream of 38463 online orders (2.2% conversion rate from 1749944 visits) for a reference month. During this month we observed 17288 click-and-collect orders and 11659 collected orders (100+ stores). The difference is explained by the time interval between orders and pickups. All simulations we made are based on these 11659 orders.

For simulation purposes, we break down this collection of real collected orders into four categories of customers/orders as detailed in Table 1. We distinguish London area (with a very high density of stores) and the rest of UK on the one hand and the CRM customers (with known habits regarding the pickup points) and unregistered customers on the other hand.

Step 1. Only if the customer is registered (i.e. not new): identify in the CRM the list of stores from S = {1, ... S} where the registered customer is used to buy products and/or pick up online orders.

Step 2. Select a candidate list of pickup stores from S again based on location (limited radius around the customer postcode).

Step 3. Randomly generate a sequence of at least S_{min} stores to be compared (duplicate stores are possible due to step 2. Filtering). This is a list of binary trials $y^t = (y_1^t, \dots, y_i^t, \dots y_S^t),\ t \in 1..T$ systematically including the output of Step 1 and randomly enriched by Step 2 selection.

For $t \in 1..T$

Step 4. Compute $p(i|y^t)$ and extract dj from o, rij and Sij from the SMS

Step 5. Solve the rounded Pli using (Lin and Vitter 1992) ε-approximation. Note that an existing solver like CPLEX can also be used

Step 6. Compute $Ri(o, x_i^*) = R^{PL}(o, x_i^*) + C_i \max_j\{0, \dots, sgn\,(d_j - x_{ij}^*), \dots\}$

Step 7. Keep the best store combination y^* and the assignment x^*according to P_o scores $\sum_{i=1}^{S} p(i|y^t) Ri(o, x_i^*)$

EndFor

Algorithm 1. Optimization Behind an Intelligent Store Locator

11659 collected orders	54% (6296) CRM cust.	46% (5363) unregistered cust.
72% (8395) London area	5023	3372
28% (3264) Rest of UK	1273	1991

Table 1. Four Categories of Customers

The aim is to simulate different behaviors according to customer categories. A London area customer has more stores in her/his neighborhood than a customer living in or near a secondary city. A customer who has already indicated which store he prefers to buy or pick up a product from will obviously be much more predictable than a customer who is not registered in the CRM. We therefore simulate different pickup behaviors through different probability distributions and vary our ($p(i|y)$ terms accordingly. The radius for selecting stores in step 2 of Algorithm 1 are different for the London area (10km) and the rest of UK (50km). We replay 3 times the 11659 orders to simulate different pickup scenarios. The key ingredients rij, Ci are given by the brand along with the real stock levels Sij which are extracted from the SMS.

We denote $|y^*|$ the average length $\sum_{i=1}^{S} y_i$ of the optimized combination of stores (output of Algorithm 1.) and P_o^* the average profitability scores. In the simulation we vary $S_{min} \in \{3,6,9\}$. After pickup simulations, we estimate the percentage NC (no carrier) of the click-and-collect orders without any transportation: the entire order is taken from the in-store stock and $\max_j\{0, \dots, d_j - x_{ij}^*, \dots\} = 0$. We also estimate the percentage ISS(in-store stock) of the deliveries that actually use at least one product the in-store stocks. All the simulation results are gathered in Table 2.

Replay	CRM customers					**Unregistered customers**				
3x11659	S_{min}	$\|y^*\|$	$100P_o^*$	NC	ISS	S_{min}	$\|y^*\|$	$100P_o^*$	NC	ISS
London area	3	3,71	2,6	4,2%	16,8%	3	4,73	2,9	5,9%	15,9%
	6	6,40	2,9	5,1%	17,1%	**6**	7,91	**4,6**	**8,3%**	28,1%
	9	9,02	2,8	4,9%	16,2%	**9**	**10,81**	4,5	7,6%	**29,8%**
Rest of UK	3	3,05	1,9	2,2%	12,7%	3	3,12	2,3	2,5%	13,3%
	6	6,01	1,5	2,4%	11,5%	6	6,21	2,4	2,6%	12,4%
	9	9,00	1,1	2,3%	8,9%	9	9,00	2,3	2,6%	9,2%

Table 2. Simulation Resultats based on 11659 Real Click-And-Collect orders

Our results give numerous insights on the click-and-collect profitability. First of all, we see that the click-and-collect facility is (much) more efficient in denser areas. If we analyze the average length of the optimized combinations of stores $|y^*|$, we see that our technique cannot work with a sparse network of stores: it is of course impossible to select 6/9 reasonable pickup points if your order is to picked from a store in the countryside! Similarly, the known habits of CRM customers guide them repeatedly to their favorite stores and simultaneously limit the power of our proposed optimization. However we see that it is obviously feasible to save money (and transport energy) especially with unregistered customers living in urban areas while maintaining a satisfactory choice and quality of experience $S_{min} \in \{3,6\}$. In this good case, 7-8% of the click-and-collect orders could be entirely delivered thanks to the in-store stocks and almost 30% could opportunely exploit at least one product from the in-store stocks. The financial gain is deductible from the optimal P_o^*score we found. The grains in profitability should not be neglected if a simple technical implementation of this optimization is proposed to a large retailer.

Implementing new omnichannel functions on top of existing IT infrastructure is notoriously difficult because of the large number and diversity of legacy IT systems and the critical properties of these systems w.r.t. usual business constraints in retail. We designed what we believe is the lightest possible integration with such systems (see also Figure 2). Therefore, we built two components in order to implement the click-and-collect solution on an e-commerce website.

The Store Locator module is the front-end part, built on top of the website and consists in a map displaying the selected stores (Figure 1). The customer can then choose the appropriate store among those selected by the module. The integration is lightweight as the module is entirely developed in client-side Javascript. The module can be added on the website via a single tag (a line of Javascript code).

The click-and-collect module is the back-end part of the system. It interacts with the existing IT systems of the merchant: with the e-commerce engine, with the CRM – Customer Relationship Management to get customer preferences about the stores and with the SMS – Stock Management System to get stock positions of the various products. Integration is light in that case as information exchange uses existing APIs and does not require any modification in the system. A transactional and robust approach in the way the back-end component is built is mandatory as this component manages the entire lifecycle of click-and-collect orders. Minimal interaction with the existing OMS (Order Management System) is required, since the module is able to receive orders directly from the ecommerce engine, manages the click-and-collect orders' lifecycle fully autonomously until the very end when the final status of an order (collected or canceled) is fed back to the OMS.

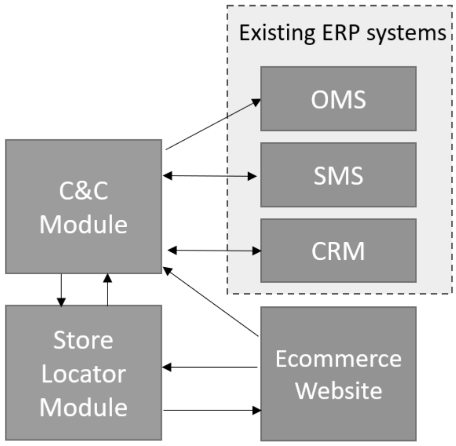

Figure 2. Intelligent Store Locator Integration.

CONCLUSION

In this article, we have shown that an intelligent decisional component can optimize the profitability of a click-and-collect service while preserving the quality of the customers experience. The main idea is to use in-store stocks to promptly fulfill the products ordered by an online shopper. We detected situations where our proposed optimization is valuable. Unregistered customers living in areas with many stores around them can be statistically guided from the web to the most profitable nearby pickup points. Both the long-term effect on loyalty and the generalization of our results obtained for one large fashion retailer (with precise stock levels, which is rare and means that uncertainties should also be introduced here) form avenues for further work.

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EVALUATION OF IOT-DRIVEN EHEALTH: KNOWLEDGE MANAGEMENT, BUSINESS MODELS AND OPPORTUNITIES, DEPLOYMENT AND EVOLUTION

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KEYWORDS
IoT-driven eHealth, Knowledge Management, Business Models, Opportunities, Deployment, Evolution.

ABSTRACT

eHealth has a major potential, and its adoption may be considered necessary to achieve increased ambulant and remote medical care, increased quality, reduced personnel needs, and reduced costs potential in healthcare. In this paper the authors give a reasonable, qualitative evaluation of IoT-driven eHealth from theoretical and practical viewpoints. They look at knowledge management issues and contributions of IoT to eHealth, along with requirements, benefits, limitations and entry barriers. They give important attention to security and privacy issues and, also, consider conditions for business plans and accompanying value chains. The authors conclude that IoT-driven eHealth can happen and will happen; however, much more must be addressed to bring it back in sync with medical and general technological developments in an industrial state-of-the-art perspective, as well as much more must be recognized to get timely the benefits.

INTRODUCTION

There are high expectations for eHealth as a major tool to achieve the following improvements in healthcare: a further shift from clinical to ambulant treatment; reductions in the per user/patient workload of medical and care staff; improvements in the quality of medical and care services for users/patients; and finally, significant reductions in the medical treatment and care cost per user/patient. The attention, and hype, around the Internet of Things (IoT), and IoT-driven eHealth, has further increased the visibility and expectation of eHealth. In this paper the authors try to give a reasonable, qualitative evaluation of what can be expected of IoT in eHealth and IoT-driven eHealth itself. They look at the possible contributions of IoT to eHealth, the requirements that need to be met, the benefits and limitations of eHealth, and the entry barriers. Important attention is given to security and privacy, representing an important set of issues. However, the authors conclude that these are not the first issues to be addressed: first there needs to be a joint understanding between the users/patients and healthcare providers that there are benefits for both the users/patients and healthcare providers in applying eHealth. This paper contributes to the literature by reviewing, innovatively, business models and opportunities for IoT-driven eHealth, as well as its deployment and evolution. The paper is organized as follows. Section two provides a theoretical view on IoT-driven eHealth in the context of Knowledge Management (KM). Section three contains study on improving patient discharge planning process through knowledge management by using IoT and Big Data technologies in the UK National Health Service, to illustrate a strong connection between KM and IoT-driven eHealth. It focuses on the contributions of IoT to eHealth, analyzes requirements, limitations, entry barriers, security and privacy, and establishes these are not the first issues to be addressed, but benefits of applying eHealth instead. Section four examines conditions for business plans and associated value chains and reflects on implementation issues and commitments. Section five contains conclusions, followed by references.

THEORETICAL VIEW ON IOT-DRIVEN EHEALTH

Views on eHealth

Everybody talks about eHealth these days, but few people have come up with a clear definition of this term. The term was apparently first used by industry leaders and marketing people rather than academics, and they used this term in line with other “e”-words such as eCommerce, eBusiness, eTrade and so on. Accordingly, how can the authors define eHealth in the academic environment? It seems quite clear that eHealth encompasses more than a technological development. The authors can define the term and the notion as follows: eHealth is an emerging field in the intersection of medical informatics, public health and business, referring to health services and information delivered or enhanced through the communication technology, i.e., the Internet, and related technologies. In a broader sense, the term characterizes not only a technical development, but also a state-of-mind, a way of thinking, an attitude, and a commitment for networked, global thinking, to improve health care locally, regionally, and worldwide by using information and communication technology. As such, the “e” in eHealth does not only stand for “electronic”, but implies several other “e’s,”, which together, perhaps, best describe what eHealth is all about, or what it should be (Eysenbach 2001; Lokshina and Lanting 2018; Lokshina and Lanting 2019).

Views on IoT

The IoT is a system that relies on autonomous communication of groups of physical objects. IoT, in the context of the digital revolution, is an emerging global communications/Internet-based information architecture facilitating the exchange of knowledge, services and goods. The authors expect that main domains of IoT will be transportation and logistics; healthcare; smart environment; and personal and social area. The applications of IoT are numerous, basically meaning smart things and smart systems such as smart homes, smart cities, smart industrial automation and smart services. IoT systems provide better productivity, efficiency and better quality to numerous service providers and industries. IoT is based on social, cultural and economic trust and associated trust management skills, which broadly speaking mean developed security services and antifragility operations. Critical issues of the IoT security field are trusted platforms, low-complexity, encryption, access control, secure data, provenance, data confidentiality, authentication, identity management, and privacy-respecting security technologies. Security of IoT requires data confidentiality, privacy and trust. These security issues are managed by distributed intelligence, distributed systems, smart computing and communication identification systems. Lastly, key systems of global economy are markets, networks and crowds. IoT can be found among these key systems of global economy. Probably, there is a lot of potential for smartness between these key systems. Data, information and knowledge about communication and interaction of these systems are vital issues for the future of management. Especially the Internet of Intelligent Things (IoIT), defined by experts as smart Machine-to-Machine (M2M) communication, provides much potential for crowdsourcing of markets and networks and smart networking. The authors expect that one obvious consequence of IoIT will be a broader scope of deliberative democracy. Additionally, the legal framework of IoT/IoIT is still considered rather vague or absent in a certain sense. Such issues like standardization, service design architecture, service design models, security and privacy, create management and governance problems, which are not completely solved inside current service architectures. IoT has also become subject to power politics because of risks of cyber war, cyber terror and cyber criminality. Finally, the authors can see that IoT will be central for the collection of raw Big Data, captured from the environment, human beings and robots and AI applications (Lokshina et al. 2018).

Views on IoT and Big Data in the Context of Knowledge Management

The Data-Information-Knowledge-Wisdom (DIKW) model is an often-used method, with roots in knowledge management, to explain the ways to move from data to information, knowledge and wisdom with a component of actions and decisions. Simply put, it is a model to look at various ways of extracting insights and value from all sorts of data, big, small, smart, fast and slow. It is often depicted as a hierarchical model in the shape of a pyramid and known as the DIKW hierarchy, among others (Lokshina and Lanting 2018). The traditional DIKW model is an attempt to categorize and simplify the key concepts involved in cognitive processes, especially when there is a need to manage large amounts of data. This theoretical model provides a hierarchy, consisting of a very large base of raw data, which, going towards the top of the pyramid, is subject to an aggregation and contextualization process, i.e., information, and application testing, i.e., knowledge. On top of the pyramid is confined wisdom, which assumes a level of knowledge that is beyond the scope of a specific application. These cognitive states are then connected in a hierarchical manner, if between them there can be a smooth transition from the bottom to the top. As in the case with all models, the DIKW model has its limits. The authors suggest the model is quite linear and expresses a logical consequence of steps and stages with information being a contextualized "progression" of data as it gets more meaning. Reality is often a bit different. Knowledge, for instance, is much more than just a next stage of information. Nevertheless, the DIKW model is still used in many forms and shapes to look at the extraction of value and meaning of data and information. One of the main criticisms of the DIKW model is that it is hierarchical and misses several crucial aspects of knowledge and the new data and information reality in this age of IoT, Big Data, APIs and ever more unstructured data and ways to capture them and turn them into decisions and actions, sometimes bypassing the steps in the DIKW model, as in, for instance, self-learning systems. The data must be of a certain type to really add value to an organization. Big Data does not necessarily mean more information: the belief, rather widespread, that more data is more information does not always correspond to reality. Among Big Data, there are obviously interpretable data and data that cannot be interpreted. Among the interpretable data, there are relevant data, i.e., the signal, and irrelevant data, i.e. noise, for our aims. Therefore, a criterion to decide whether it makes sense to think of an analysis based on Big Data would be to think about the interpretability, relevance and whether the process could extract really new information from the mass of data. However, the essence stays the same: looking at what to do with data lakes and turning data through Big Data analytics into decisions and actions, as shown in Figure 1.

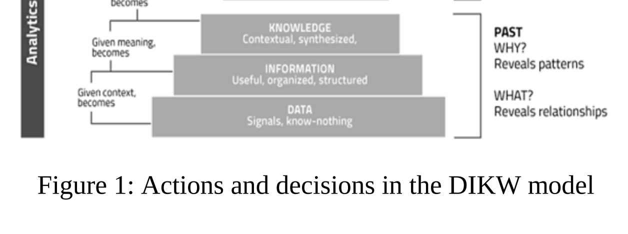

Figure 1: Actions and decisions in the DIKW model

Therefore, the authors suggest the traditional DIKW model to define, illustrate and explain the various forms of data, information, etc. in a business, transformation and customer/stakeholder perspective. What the authors are most interested in, is the decision and action part, because without decisions and actions there is little sense in gathering, capturing, understanding, leveraging, storing and even talking about data, information and knowledge. The authors consider the decisions and actions as in business and customer outcomes, creating value in an informed way. However, in the bigger picture, they assume the decisions and actions can simply be learning, identifying, evaluating, computing or anything else.

Effects of IoT and Big Data to Knowledge-Based Management Practices

Organizations use information and knowledge both for improving the quality of decisions and for legitimizing decisions including also decisions made by poor knowledge. The authors evaluate possibilities that come along with the emergence of IoT and Big Data. More generally, the authors assume that IoT and Big Data predict the new start of knowledge management and the revision of the traditional DIKW model. For instance, the authors state that society and organizations manage by planning. Resources are limited, time is limited, and planning applies thought before action. The output of planning is a plan or strategy, a statement of how something will be done. Society and organizations need to have a strategy for managing the layers and technologies, including IoT and Big Data, in the revised DIKW model. The authors suggest the basic components of a KM strategy can be generalized and used to manage decisions and actions in the revised DIKW model, including identification of users of the knowledge pyramid layers and transformation processes; identification of actionable intelligence needed to support organizational/societal decision-making; identification of sources of Big Data, data, information, and knowledge; identification of Big Data, data, information, and knowledge to be captured; identification of how captured Big Data, data, information, and knowledge is to be stored and represented; identification of technologies to use to capture and process Big Data, data, information, and knowledge, as well as to establish feedback. The authors conclude the goal is a top-down strategy approach based on decisions and actions. They note the digital revolution in management process, by developing and applying smart solutions like utilization of IoT and Big Data, impact strategies based on decisions and actions as in business and customer outcomes, creating value in an enlightened way (Lokshina and Lanting 2019).

PRACTICAL VIEW ON IOT-DRIVEN EHEALTH

Study on Improving Patient Discharge Planning with Knowledge Management by Using IoT and Big Data

The UK National Health Service (NHS), a publicly funded organization, provides healthcare for all UK citizens. The NHS is faced with problems of managing patient discharge and the problems associated with it, such as frequent readmissions, delayed discharge, long waiting lists, bed blocking and other consequences (NHS 2012). The problem is exacerbated by the growth in size, complexity and the number of chronic diseases under the NHS. In addition, there is an increase in demand for high quality care, processes and planning. Effective Discharge Planning (DP) requires practitioners to have appropriate, patient-personalized and updated knowledge to be able to make informed and holistic decisions about a patient discharge (Kamalanathan et al. 2013; Lokshina and Lanting 2019). The authors examined the role of knowledge management in both sharing knowledge and using tacit knowledge to create appropriate patient discharge pathways in the NHS. They detailed the factors resulting in inadequate DP and demonstrated the use of IoT and Big Data technologies as possible solutions that help reduce the problem. The use of devices that patients took home and devices that were perused in the hospital generated information that served useful being presented to the right person at the right time, accordingly, harvesting knowledge. The knowledge fed back supported practitioners in making holistic decisions about a patient discharge. Clearly, monitoring and understanding a patient condition after discharge was a key part of successful DP. It required the support of appropriate sensing and monitoring technologies with IoT and Big Data, so that patients with chronic conditions could live independently in their own homes or secure housing (i.e., a non-hospital setting).

IoT in eHealth

Although the authors prefer to use the term IoT for integrating so far not communication-able devices into a digital, communicating infrastructure (often based on the internet infrastructure and services), they hereafter include communicating sensor and actuator devices, aimed at measuring and, where applicable, controlling health-relevant parameters.

IoT as Enabler

The technological development of direct and indirect sensor systems, and miniaturization, are making available ever more IoT sensor systems that could make practical use in eHealth possible, and, thereby, eHealth feasible and accessible.

Gadgets and Medical Relevance

Most of these sensors require positioning and sophisticated and medical knowledge-based algorithms to make them medical-relevant. In absence thereof, unfortunately, they stay gadgets with a merely indicative value for healthy living and exercising. Moreover, smart applications and algorithms, using the facilities of the current generation smart phones, accelerometers and cameras, have created another wealth of healthy living and exercising APPs, with even more limited medical relevance.

Dynamic EHR and Dynamic EPHR

The grand vision of Electronic Health Record (EHR) infrastructures is the interconnection and reusability of all recorded health information, regardless of where it is stored, so that all relevant health information can electronically flow to wherever it is needed. Nothing will become of this vision, however, unless critical privacy and security problems are overcome. IoT devices, if designed and used to support medical applications, may become part of a Dynamic Electronic Health Record (EHR) or a Dynamic Electronic Personal Health Record (EPHR), where IoT may be used to provide the on-line, dynamic, very recent past complement to the static EHR and EPHR stored information, as well as a tool in support of security mechanisms.

System Approach Versus "Whatever" Approach

For IoT to make an important and necessary contribution to eHealth, a system approach needs to be followed, not a "whatever" approach, as is too often the case with today's wearables. In several the companies and research organizations in the world, there is the infrastructure and multi-disciplinary competence, necessary to develop IoT-based medical-relevant eHealth systems, as is shown by the laboratory prototypes, such as continuous, real-time blood pressure monitoring systems; and by pre-production prototypes, such as diabetes insulin control systems.

EVALUATION OF IOT-DRIVEN EHEALTH

eHealth Requirements

(Eysenbach 2001) gave a set of eHealth requirements, such as efficient; enhancing quality of care; evidence-based; empowering consumers and patients; encouraging a true partnership between patients and health professionals; educated; enabling data and information exchange and communication between health care establishments; extending the scope of health care beyond its conventional boundaries; ethical; and equitable. Refining this top-down, but less detailed view, the authors added several requirements for eHealth, which are defined below. Medical and/or care relevant and usable systems require collection of medical relevant data with direct and indirect practical measurement. They represent compromise between user/patient comfort and data collection quality and reliability and consist of suitable sensors used in a way matching the capabilities and limitations of the sensors. Data pre-processing requires data reduction to avoid data overflow and generation of reliable warnings (alarms) to make use of data manageable and beneficial. Data interchange and exploitation is required in combination with other IoT and non-IoT data, e.g., location information; security and privacy; trust and reliability; anonymization of data where possible; as well as on-line and off-line data post-processing with medical relevant objectives. System approach versus "whatever" approach requires the users/patients, who are active committed stakeholders/beneficiaries; the medical and care providers, who are committed stakeholders (beneficiaries); and the infrastructure and service providers, who provide installation, operations, maintenance and repair. It assumes the IT infrastructure, which includes middleware, cloud storage, cloud processing and applications; the near/on-user/patient systems and smart systems. Besides, it requires the compromise between patient benefits versus black-box/post-mortem benefits and hybrid/dialogue development approach with the top-down requirements and the bottom-up possibilities. Finally, it should be cost-benefit-driven.

eHealth Limitations

For the foreseeable future, eHealth will not replace doctors, medical experts and care providers. Instead, it must be a joint tool used together between users/patients and eHealth professionals for the benefit of both, and this has to be fully taken into account in the development and deployment. Besides, the limitations below must be considered. These limitations include the patient benefit versus black-box/post-mortem approach as it simplifies recording effects of a disease or condition instead of preventing or curing it; along with applying negative evidence gathering, e.g. non-compliance with the prescribed diet and medication instead of directly contributing to overcoming an illness or condition. The limitations also include generating warnings and alarms that are essential for the usefulness of eHealth, without risking eHealth to become the black box of Health. In its place, generating warnings and alarms is as good as the quality of the data collection and the applied algorithms; therefore, applying AI and Big Data techniques may be helpful post-processing options. However, the absence of warnings and alarms can never be taken as guarantee for the absence of risks and conditions. The unjustified cost-saving expectations, meaning the cost of installation, maintenance, technical and medical healthcare operation should be considered already in the system design and planning phase. Additionally, it is easier to achieve better quality healthcare than achieving real cost reductions.

eHealth Entry Barriers

Before eHealth becomes widely implemented and adopted, there are several barriers to overcome. The main barriers are based on functionality, which includes medical relevant data and information, time needed to accept and develop procedures and algorithms and AI to handle the reduce data, obtain information and generate reliably warnings and alarms, trust, security and privacy. Security and privacy concerns are major impediments to eHealth because if they are not properly addressed, healthcare seekers won't feel comfortable in participating, and healthcare professionals will face huge liability risks. Additionally, the entry barriers include usability and "companionship" for both users/patients and healthcare providers along with market development and the required stability in value chains and business plans.

Security and Privacy Concerns

Developing and implementing security and privacy functions in eHealth is a prerequisite for adoption by both users/patients and healthcare providers. It concerns, however, a more complex ecosystem than environments currently addressed, requiring new and more sophisticated privacy and security systems, that in turn may be used in other more demanding applications, i.e., in Industry 4.0, energy, social networks. The requirements include individual privacy, temporary and permanent sharing of subsets of private information, user-controlled access between providers, transferring ownership from a provider to the user or another provider, role-based access, etc., and, a controlled and regulated "break-glass" function for emergency situations.

BUSINESS MODELS AND OPPORTUNITIES, DEPLOYMENT AND EVOLUTION

While eHealth has a major potential and its adoption may even be considered necessary to achieve increased ambulant and remote medical care, increased quality of care, reduced personnel needs, and reduced or reduced increase in costs, the market is not developing as hoped and expected. Predominantly vertical markets have developed explosively for fitness, sports and healthy living. Their contribution to eHealth is limited, however, and the value chain less suitable for an eHealth market development. It is the unsettled configuration of the value chain that create an uncertainty in the eHealth market, or better markets, as the parameters may be different between countries or even regions, therein the separation and/or overlap between private and public health services provision; the separation and/or overlap between private and public health services insurances; the role of telecom and communications services providers; the role of equipment manufacturers; the role of equipment and communications services installation and services companies. "Asymmetries" in the value chain create a separation between costs and benefits and overlapping and/or crossed responsibilities, potentially putting investments needed and benefits at different entities in the value chain, such as investments made near the user/patients would contribute to cost savings in a hospital; and investments made in a hospital would contribute to cost savings in the public social sector. The unsettled configuration of the value chain results in uncertainty for the scope and hence of business plans. And this uncertainty in the value chains and business plans do not favor the commitment and market development, in turn leading to low interest from industry, hesitant telecom service providers and manufacturers in joint research and development and standardization, essential to arrive at coexistent and interoperable infrastructure and support for common generic and specific applications. Whereas telecom providers try to offer "premium services" for eHealth services, it could be observed that few eHealth applications require high bandwidth, low delay, low Bit Error Rate (BER) services. Instead, eHealth requires rather a reasonable high availability including a short time to repair, 24/7. And while eHealth and our whole society become more dependent on access to the internet and the services it supports, the availability of networks and Quality of Services (QoS) is not improving, but rather degrading. This may lead to the development of communications service providers that guarantee services covering support for eHealth equipment and high availability telecom services to address this gap. The time necessary for organizations to arrive, alone or together with partners in the value chain, to decisions to invest and deploy eHealth systems at a large scale is often insufficiently considered or ignored. As deployment takes significant time, and technological development keeps it pace, it is predictable that organizations applying eHealth systems will be working in parallel with several generations of equipment, using several generations of the telecom infrastructure. Regarding the functionality, it may be expected that eHealth equipment will develop into fully or partially implanted systems, with an increasingly feedback and control functions.

CONCLUSION

This paper examined theoretical and practical views on IoT-driven eHealth. Theoretical view concerned associated knowledge management issues. Practical view concerned potential contributions of IoT to eHealth, deployment and evolution. The authors concluded that IoT-driven eHealth can happen and will happen; however, much more must be addressed to bring it back in sync with medical and technological developments in an industrial state-of-the-art perspective, as well as much more must be recognized to get timely the benefits.

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IMMERSIMED: FIRST PHASE OF VIRTUAL REALITY NURSE TRAINING

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KEYWORDS
Virtual Reality, Augmented Reality, Medical Education, Simulation Training.

ABSTRACT

This work presents the first phase of the ImmersiMed platform we created to realize immersive virtual and augmented reality training. ImmersiMed is aimed at medical educational and professional institutions for educating nurses, doctors and other medical personnel. Currently, the first set of applications have been developed and implemented as an optional training module in the Bachelor in Nursing program at the Karel de Grote University College. In this work we present current status and elaborate on future developments and opportunities.

RELATED WORK

While the term Virtual Reality (VR) was coined in the 1980's, its concepts had been fueling sci-fi literature and movies for decades. Nowadays, VR refers to a computer-generated virtual environments (VE) in which users are being immersed using VR devices such as Head Mounted displays (HMD) and intuitive, motion sensing input devices. The goal of VR applications is to create an experience in which the user feels immersed and present in that VE. The focus of VR interactions thus remains in the digital environment.

Augmented Reality (AR) differs from VR as it uses the real environment but enhances the experience by adding an interactive overlay onto it. Therefore, AR applications usually focus on real world tasks. The virtual and physical environment layers are blended in such a way that an immersive, interactive environment is experienced.

VR and AR are no longer just about video games and research. Over the last few years, big players in the tech industry such as Facebook (Oculus Rift), Google (Glasses, Cardboard, Daydream), Samsung (Gear), Microsoft (HoloLens) and HTC (Vive) have invested in the future of VR and AR. The technology has since evolved dramatically, providing high-fidelity experiences at affordable prices. They are thus no longer Sci-fi vision but are a commercial reality and are on the verge of being adopted in every other industry, as well.

Training is one of the earliest use cases for VR and AR. Especially VR, which allows for practicing dangerous, complex, uncommon or expensive tasks in a risk-free environment. From a learner's point, the possibilities are unlimited, as trainees can perform 'hands on' tasks in a controlled and safe environment. Trainees can afford to make mistakes and learn from it in the VR setup where there is literally no risk at all. A comprehensive publication of the benefits of VR training can be found in (Gupta et al. 2008) Although, these benefits are numerous, a gap between the simulation and the real world remains.

As AR is a more recent technology, its advantages have not been studied in such a general way, however some studies do point out that many of the benefits that VR brings to training also hold true for AR (Barzom et al. 2016; Khor et al. 2016; Ma et al. 2016; Kamphuis 2014). Some AR applications have shown the potential of AR. Perhaps, it might be able to bridge that gap between achieving a skill in a virtual training context and the actual competence in the real world.

One of the fields that has been adopting VR for training and simulation since its early days is healthcare (Jones 2015). Over the past couple of decades, VR and simulation technology has been implemented in healthcare training and education. Surgery simulators have been invaluable for physician training. However, these tools have historically come at a considerable cost and students often only have limited access to these simulators. Furthermore, most of these setups were only designed to focus on specific procedures, scenarios or situations, mostly aimed at surgeon training. New real-time visualization platforms, such as smartphones, are now becoming ubiquitous and their power is nearing that of desktop computers. This has been pushing VR and AR technologies and is making it cheap and available to everyone. Studies have shown that the VR and AR training of medical students and residents improves students' knowledge base and in evaluating their performance (Okuda et al. 2009). Students perceive simulation-based education as ''an opportunity to learn new skills in a safe environment.'' (Weller et al. 2004). Use of VR training at the start of medical training has also been shown to improve understanding of basic concepts of medical science, such as pharmacology and physiology, presumably because these simulated experiences help students to understand abstract concepts of basic science that are difficult to perceive with regular discourse (Rosen et al 2009).

Apart from the understanding aspects, there is also an important confidence aspect. There has always been a strong mental connection between performance and seeing oneself as being successful. Visualizing yourself on the ladder of success certainly helps you boost your confidence level. And that's one of the reasons VR and AR simulations are a successful technology for training. The more medical students train and succeed in a virtual situation, the more confident they will be once they enter real-life situations. More and better training will improve quality of care and lower the risk of medical mistakes.

The healthcare industry lies at the intersection of high-tech, medical knowledge and legal policy. Medical knowledge doubles every six to eight years and new innovations in medical procedures pop up every day. Healthcare practitioners have an obligation to keep their knowledge and skillset up-to-date. Medical professional training and proficiency are a huge part of health care costs and many hospitals and educational institutions lack availability of tools and/or time to keep up with all new developments. Due to the high cost, training is often limited to pure medical knowledge. We believe a blend of AR and VR can solve these issues. As reported earlier, many tools for both VR and AR already exist in the field of medical training. However, they are mostly complex expensive and focused on fixed procedures and scenarios. The largest group of medical personnel consists of nurses, a group which we believe has been overlooked by most VR application developers and researchers. Furthermore, their technical knowledge on how to adapt VR/AR applications is mostly non-existing.

IMMERSIMED

Current Functionality and Applications

A full description of our vision on, and the short and long-term goals of, the ImmersiMed platform was described in (Jorissen et. al 2018). In this work we present the current status and developments. We refer to this work for a detailed description on the all vision related aspects of the project.

In short, ImmersiMed is a combined VR/AR platform aimed at educational and medical institutions for training, nurses, doctors and other medical personnel ImmersiMed and its first set of applications have been developed using the Unity multi-purpose cross-platform game engine. Unity was chosen for its flexibility and cross-platform capabilities. For VR support we chose to work with OpenVR and use the HTC Vive as the standard VR headset.

We use an XML-based file format to describe scenarios, including patient details, available medications and equipment, tasks the student should perform and so on. A user-friendly tool that allows nursing teachers or trainers to edit and create new scenarios was also developed. It uses the same Unity modules and codebase that were used to create the applications.

The first-phase ImmersiMed applications are aimed at training nursing students in routine tasks and providing them with feedback on how well they performed. The tasks were identified by a team of instructors from the Bachelor in Nursing program at the Karel de Grote University College. These routines include:

1. navigating through and interact with a virtual hospital environment. The subject can walk through the hallways, enter patient rooms, medical supply rooms, open, close doors, etc (Figures 1).
2. Finding, identifying patients (Figure 2) and reading their medical charts containing history, allergies, etc. (Figure 3).
3. Finding and reading instructions on the required medical treatments, prescriptions.
4. retrieving necessary medical equipment and machines from store rooms and computer-controlled medication cabinets, also known as secured unit-based cabinets (UBCS) (Figure 4). Our system is based on the Vanas computer controlled medical cabinet system which is the most prevalent in Belgian Hospitals.
5. preparing medical equipment (syringes, needles, etc.) and medications such as dosage, collecting extra aids for administrating medicines (a cup of water, etc.). (Figure 5).
6. looking up medication information in the official professional drug and medications databases.
7. Administrating medications to the patient according to professional guidelines (Figure 6).

Figure 1: Navigating through the Medical Institution's hallway, to get to a patient's room

Figure 2: A Patient's Room including a Pregnant Famele Patient. The Patient can be identified by Scanning a Code on the Wristband

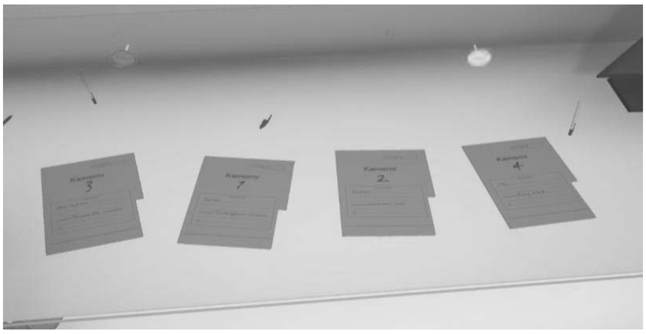


Figure 3: A collection of Virtual Patient Charts located at the department's central Desk

Figure 4: Room with Secured Medical UBCS for Retrieving Medications and Medical Equipment

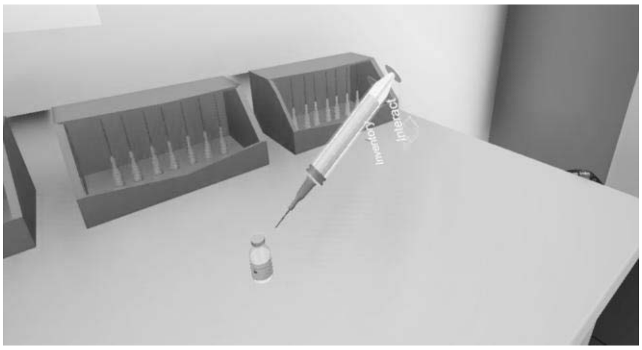


Figure 5: Drawing Up Medication from a Vial after Selecting the Correct Syringe and Type of Hypodermic Needle

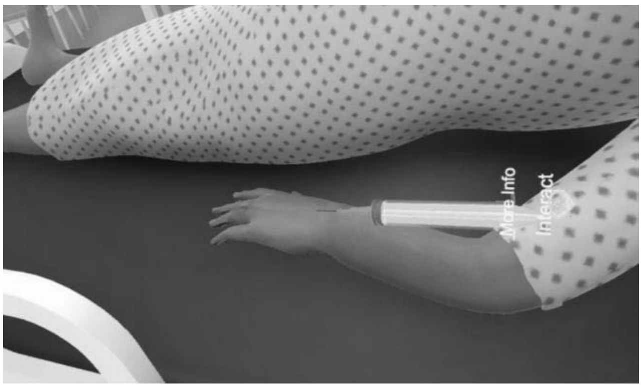
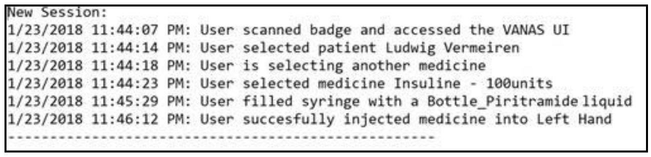


Figure 6: Administrating Medications with Direct Feedback Enabled

Instructors, on the other end, are provided with two simple tools. The first tool is a simple, easy-to-use form-based scenario creation tools which allows them to create new scenario's with custom patients, medications, medical tools and UBCS setup. Part of the interface is shown in Figure 7. A second tool for instructors allows them to check a student's progress by viewing the results after the session has ended. This progress is, for now, kept in a simple text-based file logging every timed action. An example of a very short session is shown in Figure 8. Currently, the development of a Web-based interface to view these logs and get a better visualization of student's progress, faults and successes is under development.

Figure 7: Adding a new Patient in the Scenario Creator Tool.



```
New Session:
1/23/2018 11:44:07 PM: User scanned badge and accessed the VANAS UI
1/23/2018 11:44:14 PM: User selected patient Ludwig Vermeiren
1/23/2018 11:44:18 PM: User is selecting another medicine
1/23/2018 11:44:23 PM: User selected medicine Insuline - 100units
1/23/2018 11:45:29 PM: User filled syringe with a Bottle_Piritramide liquid
1/23/2018 11:46:12 PM: User succesfully injected medicine into Left Hand
--------------------------------------------------
```

Figure 8: Part of a Log File for the Instructor

Current Status and Future Developments

After being fully tested and approved by several members of staff, the first PC-HMD setup has been installed at the faculty of Nursing and Midwifery at the Karel de Grote University College, where it will be used as one of the training tools in their skillslab (Figure 9).

Unfortunately, at the time of writing it is too soon to get results on the training effect, the first set of reactions to ImmersiMed are very promising. Both students and instructors seem very excited and keen on practicing their skills in this safe but close-to-real environment.

Figure 9: A student working with ImmersiMed for the first time.

First reactions from several student users included (translated from Dutch):

- "Amazing"
- "Why didn't we have this sooner"
- "This will definitely boost my confindence"
- "It takes a little practice, but once you get the controls, it's quite realistic"

Also, instructors are very excited to get to know the tools better and get into the development of their own custom scenarios.

The next phase will include some fine tuning of the current application. Especially typing on the UBCS's keyboard in VR is somewhat slow in the current application, and another interaction than point-and-click might be necessary to allow for faster interaction with the UBCS's interface. Apart from that, we are working on a new Web-based tool for visualizing student's result logs. This will provide more detailed instructor feedback e.g. it will allow supervisors to get a quick overview of what went right and wrong in different sessions. It would also be able to provide teachers with a a better understanding of results across different scenario's and trainings. This could lead to a better understanding of where things go wrong, and where students might need more hints in the environment or more theoretical training in advance.

Another path of research, that has already described in (Jorissen et. al 2018) is the creation of a mobile training applications to allow nursing students to practice the same skills, when and wherever and let them learn at their own pace. This is expected to increase the quality of training on the more detailed aspects of the simulation and increase students' confidence in the routines and procedures they are trying to master. Currently, we have a pending request for funding for this part of the ImmersiMed project. Creating a consistent experience across mobile and the original setup will be key, and we plan to start development in the second semester of 2019.

A third research opportunity in the short term, is the addition of Artificial Intelligence (AI) and speech recognition. The combinations of these techniques could be used to create more lively and realistic characters. This could be anything from basic patients telling their names when asked, to fully operational colleagues who or virtual instructors or internship supervisors. To fund the investigation of these technologies into ImmersiMed, requests for funding have been filed. Our main focus would be on:

- Using chatbot technology to allow for basic conversations between the student and virtual patients (ask for name, date of birth, …)
- Create a tool with standard behaviors, in order to allow instructors to create realistically behavior in agents representing colleaques of the student in the virtual world (e.g. point out things students might be forgetting, help with the UBCS's interface, …)

A lot more would be possible, once the basics have been created, but those would be the first things we would be implementing. So, just like with the scenarios we do not aim at providing predetermined agents or voice interactions, but we aim to provide generic tools for instructors These will allow for the creation of their own agents and speech interactions, without the need to know all the technical details. Leading to a much more flexible result, and an unlimited set of possibilities and applications.

Other long-term research plans have been delineated in (Jorissen et. al 2018)

CONCLUSIONS

In this work we present the current status of the ImmersiMed project. ImmersiMed is a platform aimed at educational and medical institutions for training, nurses, doctors and other medical personnel. Currently, the first phase of ImmersiMed and its applications are being deployed in the skillslabs at the faculty of Nursing and Midwifery at the Karel de Grote University College on top of the Unity multi-platform engine. It allows students to practice in routine tasks and they get provided with feedback on how well they performed. Tools for educators provide the possibility to create new scenarios without intervention of expensive content creators or programmers. We elaborated on the next steps we will be taking in this project to continue creating more realistic and better training at lower costs and with less risk than in real-life situations.

ACKNOWLEDGEMENTS

We gratefully acknowledge the support of the Department of HealthCare, at the Karel de Grote University College, especially Rik Depauw and Dieter Smis for their input and feedback. Furthermore, we thank the third-year students in Multimedia Technology at the Karel de Grote University College specializing in Virtual & 3D for their work on 3D models and support developing the first set of applications.

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