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FitOptiVis

From the cloud to the edge - smart IntegraTion and OPtimisation Technologies for highly efficient Image and VIdeo processing Systems

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1 Executive summary

This deliverable is meant to report the results of WP7 during the first project year.
The deliverable reports on the activity of all the three tasks of WP7 and will focus on both exploitation plan related to the 10 use Cases, the standards that have an impact in each domain, complemented with the IPR management and a very preliminary draft of the Open Source exploitation activities.

2 Introduction

The WP7 work package is the main responsible of defining the roadmap to exploit all the project outcomes and results during and after the project, including the definition of a set of strategies to implement successful impact in the very large set of markets addressed by FitOptiVis technologies and the analysis of the sustainability of our solutions beyond the duration of the project and the use of the project outcomes by stakeholders outside of the consortium.

The idea is to try to define common joint strategies where possible and to verticalize them in specific key application scenarios. On top of that, this WP7 will contribute to perform continuous market watch, and to facilitate innovation-related aspects specifically intended to pursue the goals outlined in Europe's 2020 strategy.

In general, the WP7 package has the responsibility to investigate and support the exploitability of the project's results and to propose realistic exploitation models, to exploit the project's results to the proper user community and to protect the IPR of the project partners. Important exploitation goals of the project are the sustainability of our solutions beyond the duration of the project and the use of the project outcomes by stakeholders outside of the consortium. The successful exploitation of project results is key to the wide-scale uptake of our solutions by the user communities.
The main responsibility for the commercial exploitation will be carried by the industrial partners in the FitOptVis consortium with the support from the academic partners and the research institutions, that will be deeply involved in the task 7.2: Open-Source Strategy and Educational activities.

The main outcome of WP7 is the strategic plan for exploitation of the results to proactively respond to market and/or technical opportunities. This plan, developed by and with the partners, analyzes important aspects such as market possibilities, business model, IP deployment, joint exploitation possibilities, and, above all, it fosters innovation-related activities. IPR strategy planning and standardization, Open-Source and Educational activities. In order to reach this challenging but fundamental goal for project success, the first year of FitOptiVis project has been devoted to analyse the reference market opportunities for the 10 use case domains:

For each use Case the following aspect has been reported:

- The **Business Opportunities** describing the demand for the innovation in each domain, considering the demand of new solutions and the potentiality to create new markets.
- What **Innovations** will be introduced in this market and also if this innovation could be further exploited in other similar domains not currently included in FitOptiVis.
- The **Product Requirements** that will be directly satisfied by the results produced during the project lifetime.
- The **Total Market Size** and predicted trends, for measuring the total market that will be directly impacted by FitOptiVis results.
- The **Commercial State of the Art and a Market Analysis**.

Finally, for each application domain the standards that have to be considered or can be influenced by FitOptiVis results have been analysed, in order develop the strategy for standardization initiatives.

The deliverable also included the IPR Management, and a first draft of the Open Innovation strategy of FitOptiVis project.

3 Water Supply Use case

This use case is led by Aitek and SAT.

3.1 Business Opportunities

After the (terrorist) attacks to people and buildings that happened in the last years all around the world, sensitive infrastructures' security has become one of the priorities of every Company who manages an essential service for the citizens. SAT delivers potable water to about 50.000 Citizens residing in La Spezia province, and delivering safe potable water is one of the deepest concerns of them. It is important for the Company to reduce at the minimum possible level the risk of deliberate attacks made to cause damages. The main threat that SAT has to face is the attempt of poisoning water before it is delivered to the end users.

This need for security becomes even stronger because of the sector in which the Company operates: potable water production and distribution even a failed attack can be very dangerous, since it can cause panic in the population. Consequently, it is very important for the company to try to defend its infrastructure from the attacks coming from outside.

The fact that the pipeline is made of iron, has a diameter of 450 mm and runs for the majority of its length underground at a very high working pressure (8 to 12 bars depending on the season) strongly reduces the possibility that someone could poison the water introducing something along the pipeline: as a matter of fact, it is very difficult to have the needed knowledge and the necessary tools to introduce substances in a high pressure pipeline of that size.

For this reason, the main issue for SAT is the protection of the wells' fields and tanks. All wells' fields and tanks are fenced, but it's not impossible for someone to break in and damage the infrastructures or poison the water.

This risk can be reduced introducing video surveillance in these locations. The installation of video cameras is of course very important, but cameras are very useful to understand ex post what happened when a problem has already occurred, but they are not very efficient to understand what's happening, unless there are people constantly watching the images dedicated to this "task". Using workers for these purposes usually generate costs that a small company like SAT cannot afford.

The use of cameras for active security purposes can be much more effective with the use of devices that analyse images using artificial intelligence techniques. This could be very useful, because it will be possible to fire an alarm when something suspicious is happening without dedicating any human resource to this task.

In particular, face recognition, artificial intelligence and machine learning software can be used to be aware of unauthorized access to sensitive areas, while and to reduce the number of errors and false alarms in the activity of discovering suspicious behavior. Since wells' fields are usually located in the countryside, it is also important to identify if that intrusion is made by an animal or by a man: in the second case it is also very important to analyse through the images what this person does inside the wells' field to

understand if he is there for work (e.g. a sales representative visiting one of SAT employee) o if it's there to try to damage something.

With artificial intelligence an analysis of what it is happening in the wells' field can be done without human intervention, and this can be a real added value to companies' everyday life. Although the system should be "trained" by Company's employee to understand what's happening and to reduce false alarms, at the end of the tuning activities this system could be very effective in reducing intrusions' related risks.

Since FitOptiVis project aims to **reduce the energy and data consumption** in retrieving, managing and transmitting images, it is sure (or at least very probable) that all these processes will be cost effective. Transmitting images with low data consumption is very important to protect remote infrastructures: sometimes building, tanks etc. are located in remote locations and in the majority of this cases data communication is very slow and big amounts of data cannot be used.

3.2 Innovations Introductions

Security of sensitive infrastructures and, more in general, security of companies' work environment is a priority for every business organization in the world.

A cost-effective product that, without the use of dedicated personnel, is able to analyse images to understand if what is happening can be dangerous for people and/or goods can be considered interesting for every company in the world.

Of course, companies that manage sensitive infrastructures should be informed of the new system as soon as a product like this arrives in the market, but it is possible to think that all the companies that are already using tools for video surveillance will be very interested as well: at the end, every company concerned about its people and assets can be a potential customer of a product like this.

An interesting development of this hardware-software system could be the interface with the existing companies' managing software: for example in our use case and in all the potable water sector, the fact that this software can communicate with the SCADA System would be extremely useful, due to the fact that an already existing and tested platform can be used to spread the alarm and to make concrete people inside the Company aware of the threat's presence.

For any other market sector, the communication between this software and the most common used ERP can be a real point of strength.

<u>Road safety control in critical scenarios:</u>

Road tunnels are critical scenarios where dangerous events are more frequent. Consequently, they are technologically complex infrastructures with heterogeneous systems like aeration, fumes control, traffic light, CCTV system, entry barriers, lighting system, I2V communication system, etc. Usually they are managed by different supervisory and control systems. The integration of the different systems, as done in UC1 for the water supply scenario, offers the following advantages:

- Intelligent decision support available to operators

- Implementation of (semi)-automatic event management procedures (accidents, fires, etc.)
- Improved road safety and more efficient critical events countermeasures

Lots of heterogeneous sensors and actuators are installed inside the tunnel (smoke detection and temperature sensors, SOS signaling columns, access control system, traffic lights). Moreover, there are also video surveillance systems with video analytics able to detect dangerous events (like intrusions, stationary vehicles, queues, speed-drops, wrong-way vehicles and smoke) in real-time.

For example, when the video analysis system detects the presence of a stationary vehicle or an accident can immediately result in an alarm to be sent on all available information channels sending a message to warn incoming vehicles (properly equipped with an OBU) of the presence of the danger; writing a specific message on the VMS outside the tunnel; activating the removal procedures of the vehicle, alerting, if necessary, police, medical support, fireman.

Similar procedures for autonomous reaction or assistance to the operator are foreseen when a smoke alarm coming from the VCA is correlated with the temperature and carbon monoxide sensors. In this case, the ventilation system will be activated/deactivated autonomously, the alarm messages and the evacuation procedures will be propagated with the same methods provided in the previous example.

Safety and security in Industry 4.0

Every Company that has security needs related to intrusion detection could be a potential customer for this FitOptvis product- innovation: in some cases, the needs of the companies will be very similar to the one described before and the product will be very similar to the one that will be developed for this FitOptiVis use case, in other cases little or big adjustments will be needed.

What will be different is the level of security needed, but for the Companies that do not have this kind of needs only a very light personalisation will be necessary to allow the product to work effectively.

Looking at the market in a wider way, we can affirm that this product could be bring innovation to all companies that are using cameras for purposes of video surveillance: of course an analysis of the needs of every sector will be necessary to adapt the FitOptivis product to the need of the companies operating in that sector.

Companies that use video surveillance but with employees watching the images on screens will need just few customizations to use the product: for example in a Supermarket a light tuning of the algorithm will be needed to make the system ready to understand the typical actions that are considered worth of note in that environment. But the product that will be the result of our project will be already usable also without any customisation.

In other sectors the tuning activity needed will be deeper, but not impossible. For example, in a parking lot an automatic anti intrusion system could be highly evaluated, and a system that can acquire data coming from heterogeneous sensors and analyses images with the skills of artificial intelligence can be very useful for a bunch of needs. An increase of temperature or smoke captured by specific sensor can be related to the beginning of a very dangerous fire, but can also be caused by normal activities. An analysis of the images of the zone in which the change of environmental conditions has

happened can give confirmation of the presence of the danger or can understand that the increase of temperature or smoke is related to events that do not represent a threat: the owner of a box located inside the parking lot doing some work inside his property or a queue of cars that are waiting their turn to leave the parking lot in the rush hour are not something to worry about, while a car covered by flames is by all means an event to take care of.

Of course, as already said, a deeper customisation of the product will be needed: according to the requirements that must be addressed, probably a big change of the algorithm will be necessary, but it's not impossible to think to broaden the field of application of the product to almost any known business sector.

In this sector too an interface of the FitOptiVis system with the existing managing software could be very appreciated: operating in this way would allow to spread the alert through already used channels, minimising the risk of rejection of the product because it's too expensive to change their current way of working.

The interface of the software with the leading managing software in the sector will make possible to target as Customers not only the end users (the companies who manage parking lots in our example) but also the companies that sell managing software to the end user. It's not difficult to believe that a system like FitOptiVis that can manage risks that are deeply felt in the activity but that are not managed yet in an automatic way is very interesting for the companies that sell software to the parking lot managing companies and can become a strength for selling their product in the market: this means that it will be very easy to increase the number of sellers that will try to sell the product, and this usually means that will be faster to install the products in the end users systems.

3.3 Product User Requirements and Differentiation

Different VCA modules, aimed at detecting different events

The video processing pipeline developed for water supply monitoring, in FitOptiVis, can be applied as previously stated in different applicative domains. While using the same system architecture, different requirements will determine the definition of different video processing algorithms, following the same approach (i.e. based on deep learning) but focusing on different events detection. For example, the traffic monitoring video analysis will detect different types of events, such as vehicles stopping in dangerous area or moving along a forbidden direction, queues, accidents etc. Also, in this case, the detection is needed to trigger various mechanisms that can be used to assess an adequate response to the event.

Similarly, this system is easily transferable to video analysis in other different scenarios, simply modifying the specific processing algorithms while using the same platform architecture.

Resource optimization

As some of the water supply facilities have difficult access to power supply it will be necessary to put emphasis on resource optimization. This requirement is less relevant in other domains (like road and industry monitoring) where there is an easy access to power supply (e.g. event detection in a highway tunnel or in a train station). Therefore, this part of the system could be reviewed.

Safety vs Security

While water supply monitoring is mainly a security related activity (that could have some indirect impact also on safety, if for example a malicious intruder tries to poison the

water,) road monitoring has large direct impact on safety. Therefore, in water supply management a false alarm will not have critical consequences at least from a people safety perspective. However, in a road monitoring scenario, a false alarm (e.g. an erroneous detection of a vehicle crash) could determine even a more dangerous situation inducing incorrect driver behaviors. Information integrity as well as automatic countermeasures should be reconsidered deeply according to this perspective.

Different reaction times
Another differentiation of requirements according to the applicative domain, regards hazard detection and reactions time. Video analysis focused on traffic monitoring has reaction time in the order of seconds meanwhile the event detection in water supply monitoring can be in the order of minutes. As a matter of fact, triggering an alarm that warns a vehicle from an accident has to be immediate but the same alarm warning that an intruder has entered a water supply facility is not as urgent.

3.4 Total Market Envisioned

The market is estimated to grow from USD 1.48 Billion in 2018 to USD 3.38 Billion by 2023, at a CAGR of 17.93% between 2018 and 2023. The major factors driving the growth of the infrastructure monitoring market include catastrophic failure of the infrastructure that results in loss of lives and incurs higher costs, stringent government regulations pertaining to the sustainability of structures, and aging infrastructures and the superior benefits of infrastructure monitoring [1]

The global critical infrastructure protection (CIP) market size was valued at USD 57.23 billion in 2016. It is anticipated to register a CAGR of 10.1% over the forecast period. Cybersecurity of nation's asset is vital and thus, securing cyberspace is of utmost importance in growing digitization. Rising concerns regarding advanced threats such as cutting populations off from clean water, power, transportation, and emergency supplies, thereby disrupting economy and nation, are one of the key trends escalating market growth [2].

The critical infrastructure protection market size is estimated to grow from USD 110.41 Billion in 2017 to USD 153.16 Billion by 2022, at an estimated Compound Annual Growth Rate (CAGR) of 6.8%. The base year considered for the study is 2016 and the market size estimated is from 2017 to 2022 [3]

Geographically, North America has been the largest market for critical infrastructure protection, owing to strict government regulations and best practices adopted by several associations such as North American Electric Reliability Corporation (NERC), which handles critical infrastructures. The Middle East and Africa is the second largest growing region in the critical infrastructure protection market. The high market growth is due to increasing number of sensitive infrastructures and organizations in the region, which leads to increasing security needs for their critical infrastructure, resulting in flexibility against cyber-attacks. The market in Asia-Pacific is expected to witness the fastest growth during the forecast period [4].

3.5 Commercial State-of-the-Art and Competitors Analysis

According to [4], some of the key players in the global critical infrastructure protection market are BAE Systems Inc., General Dynamics Corporation, Honeywell International

Inc., Lockheed Martin Corporation, Airbus Group SE, Intergraph Corporation, Intel Corporation and Waterfall Security Solutions Ltd

As reported in [3] the major vendors in the critical infrastructure protection market include: BAE Systems (UK), General Dynamics Corporation (US), Honeywell International Inc. (US), Lockheed Martin Corporation (US), Northrop Grumman Corporation (US), Raytheon Company (US), Airbus Group SE (Netherlands), Hexagon AB (Sweden), Johnson Controls International plc (Republic of Ireland), Thales Group (France), Teltronic S.A. (Spain), OptaSense (UK), Motorola Solutions, Inc. (US), Huawei Technologies Co., Ltd. (China).

3.6 Standardization Activities

According to a survey proposed by European Community [5], the list of standards relevant for the water supply system management is reported below.

- ISO/TC 147 [6]: Standardization in the field of water quality, including definition of terms, sampling of waters, measurement and reporting of water characteristics.
- ISO TC 224 [7]: Standardization of the management concepts for service activities relating to potable water supply, wastewater and storm water systems. This structure includes activities necessary to fulfil the objectives of water supply, wastewater and storm water systems. Water supply for purposes other than drinking water can be included in this management concept structure.
- ISO/TC 292 [8]: Standardization in the field of security to enhance the safety and resilience of society.
- CEN/TC 164 [9]:To establish standards for installation and performance requirements of systems, constructions of components used for the water supply from the production facility, including the treatment of the water, to the taps attached or unattached to a sanitary appliance with the view of maintaining the quality of water as stated in Directive 80/778.

Considering FitOptiVis and in particular use case 1 focus, the standard **ISO/TC 292** is the one which can be more influenced by the project results.

3.7 References

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4 Virtual Reality Use case

This use case is led by Nokia.

4.1 Business Opportunities

Advances in 3D sensing and capturing technology have unleashed a new wave of innovation in Virtual/Augmented/Mixed reality (VR/AR/MR) content creation and communication, as well as 3D sensing for smart city, robotics and automated driving applications. There is now a huge interest from the virtual reality market in being able to represent digitally the real world in three dimensions, thus enabling the end-user to freely navigate in this digital representation.

Volumetric visual data describes a 3D scene and objects with its geometry (shape, size, position in 3D-space) and respective attributes (e.g., color, opacity, reflectance, albedo), plus any temporal changes. Such data is typically computer-generated from 3D models or is captured from real-world scenes using a variety of solutions such as multiple cameras or a combination of video and dedicated geometry sensors.

Common representation formats for such volumetric data are polygon meshes or point clouds. Temporal information is included in the form of individual capture instances, similar to frames in a 2D video, or by other means, e.g., position of an object as a function of time. Because volumetric video describes a complete 3D scene or object, such data can be visualized from any viewpoint. Therefore, volumetric video is a key enabling technology for any AR, VR, or MR applications, especially for providing Six Degrees of Freedom (6DoF) viewing capabilities.

As for all 3D representation models, point clouds are better targeted to some specific applications and conditions, for instance applications working with a lot of volumetric data and involving user interaction. They are also commonly used for inspection purposes, due to their simple and fast rendering, and real-time applications like telepresence. To make these applications effective, appropriate point cloud coding solutions have to be developed while fulfilling the needs of relevant applications. Based on the MPEG relevant documents, several groups of applications can be identified for envisioned product candidates.

4.2 Innovations Introductions

3D point cloud data finds applications in many fields, including cultural heritage/museums, 3D free viewpoint video, real-time immersive telepresence, content VR viewing with interactive parallax, mobile mapping, and autonomous navigation. Regarding cultural heritage applications, point cloud data scans are used to archive and visualize objects in museums including historical statues and buildings.

Typical point clouds in this use case may contain from millions to billions of points with finer than 1 cm of geometric precision and an 8-12 bits per color component accuracy. The goal of immersive video is to go beyond higher image quality (4K/8K TV) and to provide a higher sense of 3D user experience and interactivity.

Real-time 3D telepresence is one of the key applications of immersive video and 3D point clouds, for which a collection of random and unrelated points is a preferred data

representation format because of its simplicity for visualization, filtering and editing. Some industrial examples of 3D telepresence include Microsoft's Holoportation and 8i's volumetric video technology.

Variations of immersive video include HMD (head-mounted display) based VR and 3D free viewpoint sports replay and broadcasting, which may not require real time processing and may in addition contain mesh based graphical data content. Such media-related use cases may usually contain between 100 000 and 10 000 000 point locations and color attributes with 8-10 bits per color component, along with as some sort of temporal information, similar to frames in a video sequence.

For navigation purposes, it is possible to generate a 3D map by combining depth measurements from a high-density laser scanner, e.g. LIDAR, camera captured images and localization data measured with GPS and an inertial measurement unit (IMU). Such maps can further be combined with road markings such as lane information and road signs to create maps to enable autonomous navigation of vehicles around a city.

This use case requires the capture of millions to billions of 3D points with up to 1 cm precision, together with additional attributes, namely color with 8-12 bits per color component, surface normals and reflectance properties attributes. To address this wide range of applications, the MPEG PCC standardization activity created three general categories of point cloud test data: static, dynamic, and dynamically acquired.

3D immersive telepresence

This type of applications usually involves real-time communication between two geographically distant sites which should be as realistic and transparent as possible. Often these applications involve the usage of virtual reality technology, where virtual objects represented by means of point clouds are placed in the real world and displayed on a TV or HMD. Figure 1 shows an example where a little girl is being recorded in real-time by a set of cameras, as shown in the top left of the figure, and the corresponding coded point cloud data is being transmitted, and after rendered and finally displayed at the user headset, in this case a Microsoft HoloLens HMD. At the bottom left of the figure, the actual footage on the HMD is shown. As this type of application normally includes (bidirectional) conversation, it has some specific demands, for instance real-time encoding and decoding, lossy compression and error resilience.

Figure 1: Telepresence environment using a HoloLens HMD

3D broadcasting

3D broadcasting of sports like basketball and baseball may use free viewpoint video, as shown in Figure 2. This is another type of application for point clouds where users can interact with the rendered video to change the angle of view. Replay Technology is an example of such applications. In this case, interoperability is usually important, this means the coding and file format must follow standard solutions in order the devices from multiple manufacturers may still interoperate. The requirements must consider low delay encoding and decoding as well as color attributes coding, with 8-12 bits per component. Unlike telepresence, 3D broadcasting of sports usually contains clusters of point clouds, as they are usually used to represent more than one player at a time.

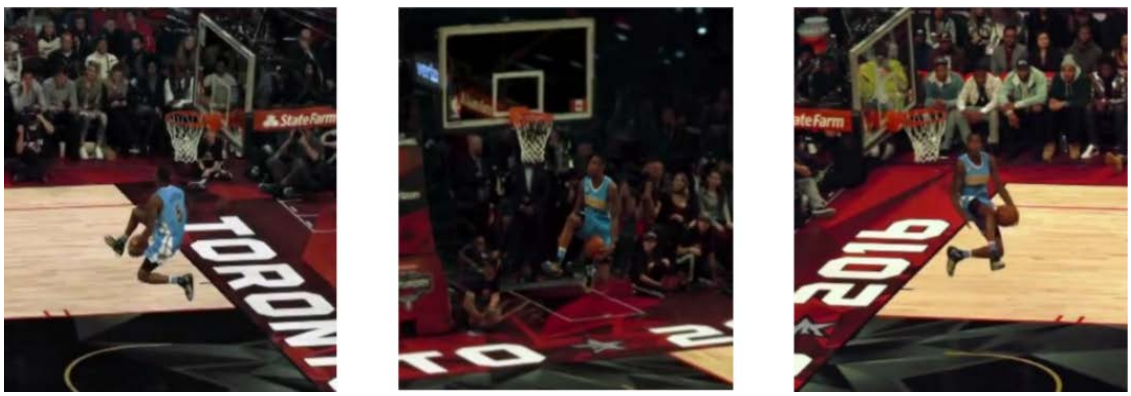

Figure 2: Different perspectives of a basketball player at the same time instant.

Geographic information systems

Another important application area for point clouds is geographic information systems, where some software application shall render, analyse and control a geographic area, represented using a typically large point cloud, see Figure 3. To obtain high precision

and resolution, some geographic information systems use Light Detection and Ranging (LIDAR), and Synthetic Aperture Radar (SAR) sensor technologies. Their measurements may provide a very dense set of points, this means a dense point cloud, which often requires a remote server to store the data. To limit the servers' capacity, there is a need to efficiently represent the large point clouds by using appropriate, ideally standard, coding solutions. These applications typically consider requirements such as region selectivity, lossless compression and progressive decoding.

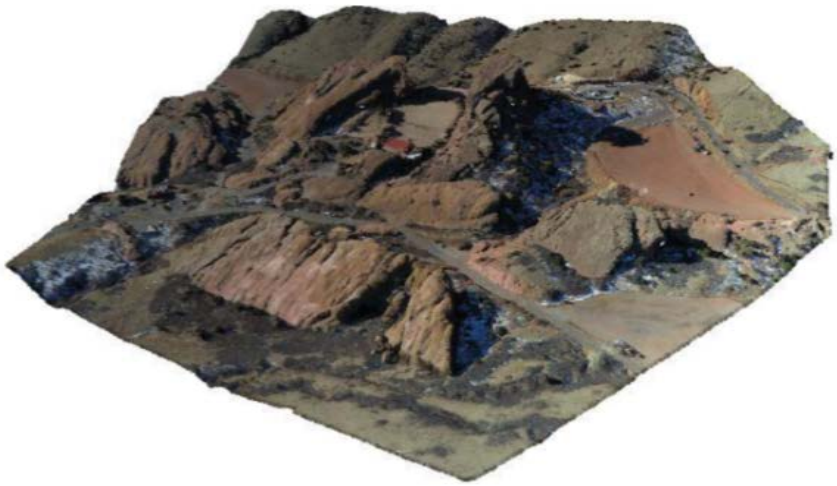

Figure 3: Point cloud of Red Rocks, Colorado.

Cultural heritage

Another application for point clouds is the representation and reconstruction of objects from cultural heritage exhibitions and collections to be interactively visualized by the users. Figure 4 shows an example of a display for this type of applications, where the user can freely rotate the object to get new perspectives. These objects are scanned with 3D laser scanning technology, like LIDAR or structured light. Relevant requirements are progressive coding, lossless coding and color and material attribute coding, e.g. to provide streaming to a wide public audience.

Figure 4: Models of cathedral and column.

4.3 Product User Requirements and Differentiation

The applications listed above allow identifying a set of requirements and differentiation features, which MPEG has also been listing as follows:

- Lossless compression: As this requirement is relevant for some geographic information systems, the point cloud codec shall allow performing lossless coding of the point cloud, including both geometry and attributes. This means that the decoded point cloud is mathematically equal, notably with the same number of points and attributes, to the original point cloud (before coding).
- Lossy compression: As some transmission channels cannot afford the high bitrate that is needed to losslessly represent a point cloud data, the point cloud codec shall be able to perform lossy coding to reduce the resulting channel bitrate, eventually at the cost of some quality degradation in the decoded point cloud.
- Progressive compression: The point cloud codec shall allow the progressive coding of the point cloud, which means a coding/decoding process based on several layers where each layer may be associated to a growing number of points, quality, etc. naturally at the cost of growing rate.
- Error resilience: To avoid propagation of errors and the corresponding negative subjective impact, the point cloud codec should be as error resilient as possible, e.g. limiting the propagation of errors in time.
- Low complexity: Some applications are to be made available in computational and battery scarse conditions, and thus low encoding and decoding complexity are critical requirements.
- Low delay coding: Some applications, such as telepresence, have to work in real-time and thus the delay corresponding to coding operations, this means the delay independent of the available computational resources, should be limited.
- Colour attribute coding: The point cloud codec shall include the capability to code colour attributes.
- Material related attributes coding: The point cloud codec shall include the capability to code additional attributes, notably material related attributes, e.g. to support efficient rendering.
- View dependence: The point cloud codec shall allow to code point cloud attributes that vary with the visualization angle, this means being view dependent. As example, although not common, the colour attributes for each point may change with the incident direction of the viewpoint.
- Selectivity: The point cloud codec shall allow easy (random) access to the cloud points associated to a specific region (subset of the point cloud).

As the full set of requirements is quite demanding, some trade-offs come naturally, e.g. a point cloud lossless codec may not have a great performance in rate reduction while a lossy codec may increase its compression if the complexity and delay requirements are less demanding. The actual point cloud coding solutions should be flexible enough to accommodate various requirements trade-offs, as there are no codecs that are able to perform the best in all requirements simultaneously. Naturally, some specific coding solutions may achieve very good performances for some specific requirements, making them ideal for the applications where these requirements are critical.

4.4 Total Market Envisioned

According to the various forecasts VR/AR/XR market will grow fast during the next few years. The general trend presented in all forecasts is that the growth derives first from consumer uptake of VR gear and content. This is mainly based on games. Later on the growth comes mainly from the industrial uptake of AR technology and services.

International Data Corporation (IDC) predicts that the VR/AR market will grow during the period of 2017-2021 by 100% or more annually [1]. Total spending on VR/AR products and services is expected to grow from USD 11.4 billion of 2017 to USD 215 billion by 2021.

The biggest territories in 2017 are USA ($3.2 billion), Asia/Pacific excluding Japan ($3.0 billion) and Western Europe ($2.0 billion). By the end of the forecast period USA will hold its leading position but Western Europe will pass Asia/Pacific excluding Japan area.

According to IDC the largest source of VR/AR revenues in 2017 is consumers. However, during the following years other segments such as process manufacturing, government, retail, construction, transportation, and professional services will pass the consumer segment.

IDC sees that the industry cases that will attract the largest investments are expected to be retail showcasing ($442 million), on-site assembly and safety ($362 million), and process manufacturing training ($309 million). By the end of the forecast period, the largest industry use cases will be industrial maintenance ($5.2 billion), public infrastructure maintenance ($3.6 billion), and retail showcasing ($3.2 billion).

The consumer segment spending will mainly consist of games with total spending growing to forecasted $9.5 billion by 2021.

All in all, IDC predicts that spending on VR systems (including gear, software, consulting services, and systems integration services) will be greater than AR-related spending in 2017 and 2018, largely due to consumer uptake of hardware, games, and paid content. After 2018, AR spending will pass VR spending due to the industrial AR uptake.

ABI Research predicts that the value of all kinds of VR content (360, interactive and immersive video) will generate USD 6 billion by 2022 [2].

PwC's prediction is more positive than ABI's [3]. PwC forecasts that VR video revenue will exceed interactive application and gaming revenue by 2019 in the following way in the Figure 5.

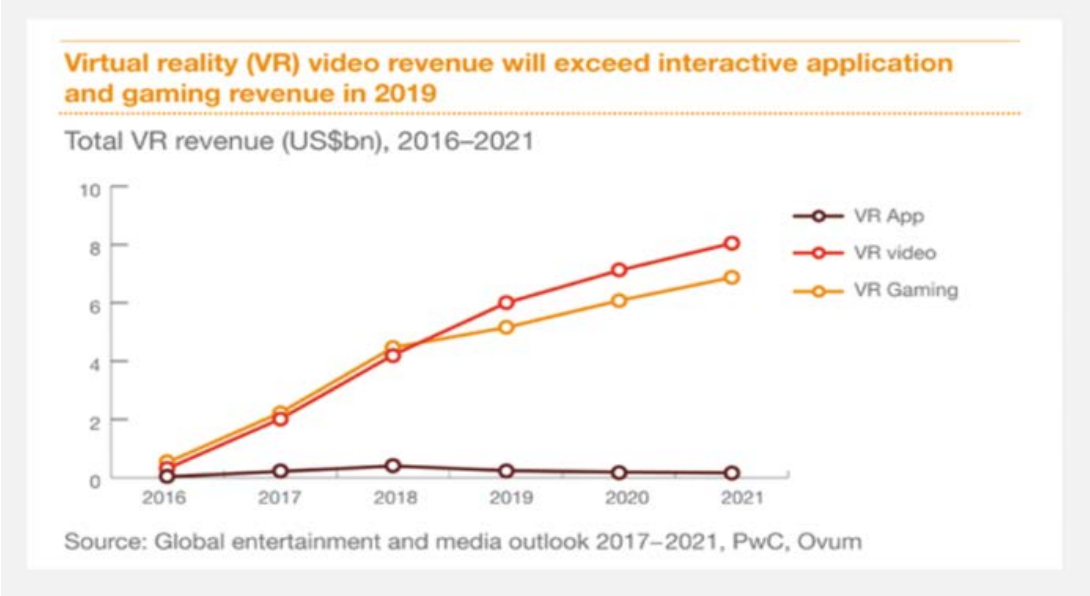

Figure 5: Global entertainment and media outlook 2017-2021 by PwC [3].

All in all, the fore-mentioned forecasts predict the same trends: the VR/AR market will grow fast during the next few years, but the “hockey stick” growth will not be seen until the 2020’s.

However, as the market is in its infancy and the level of uncertainty of predicting many essential factors is high, the current forecasts are varied in terms of the actual value. Furthermore, the bases of the various calculations are not necessarily the same.

4.5 Commercial State-of-the-Art and Competitors Analysis

The active companies in the field are as follows:

- Nokia Technologies
- Samsung Electronics
- Google
- 8i
- Technicolor
- Sony Corporation
- Apple
- Huawei
- Sharp
- LG
- Ericsson
- Blackberry
- MediaTek
- Tencent

4.6 Standardization Activities

While MPEG in prior standards has already addressed the coding of 3D worlds, specifically computer-generated worlds, recently it launched an ambitious road map of technologies for coding representations of real 3D scenes. One of these technologies is called Point Cloud Compression (PCC) and is expected to be delivered as an ISO standard in the beginning of 2020.

In 2017, MPEG issued a call for proposals on PCC, and since then it has been evaluating and improving the performances of the proposed technologies. Such point cloud data presents new challenges to the signal processing and compression research community.

Previous compression solutions for volumetric visual representations either focused on computer-generated content, or suffered from low spatial and temporal compression performance, when dealing with captured natural content. For natural captured 3D sensor signals, scene geometry needs an efficient representation that is scalable in level of detail and efficient in compression, while its photometric attributes are a new class of signal that is not sampled on an uniform Euclidean grid and therefore needs new sampling, filtering, and transform tools to represent and compress.

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5 Habit Tracking Use case

This use case is led by RGB Medical Devices

5.1 Business Opportunities

The Habit Tracking use case is mainly applicable to elderly population. The objective is to assess their current physical habits and identify the situations where methodological and behavioral concepts can efficiently promote physical activity and healthy lifestyle. FitOptiVis Habit Tracking use case will help people in their journey towards a healthier and more balanced way of life. We achieve this by a behavioral change trajectory in which we give individuals the opportunity to change their unhealthy habits and create strong competencies. The HTS will also help detect deviations from a standard behavioral pattern. Thus, by analyzing daily activities, some potential deterioration of user's health or wellness will be assessed by FitOptiVis platform.

This use case is meant to decentralize patient care, moving it outside hospitals, favoring the decrease of hospitalization costs and increasing equality of care for people that live in isolated environments. On top of that, the technologies to be developed are meant to improve patients' quality of life, making preventive healthcare of elderly and distant people more accessible.

In current ageing European societies, one of the challenges is to keep specially the elderly safe and monitored continuously, bearing in mind the protection of their privacy and their personal safety. This need is justified with the reduction of costs of hospitalization (especially chronic patients) and the improvement of the comfort and quality of life of citizens from either urban or rural areas [1][2]. For example, there are already a number of applications that have given rise to the starting of business in this sector, in the so called "Tele-alarm" business. Probably, one of the highest ranked companies is Tunstall (http://www.tunstall.co.uk/solutions/products). Its web is a good approach to the current state of art in the different services delivered at home for elderly living. The concept behind is "How to make use of an independent life".

In order to achieve this goal, the concept, and the platform and components that we will develop within the framework of FitOptiVis will provide a solution that is proposed in this Habit Tracking System (HTS) use case. One of the core components of the HTS is the video processing pipeline for real-time performance targeted by FitOptiVis. The use of a multi-view (multi-camera) video processing system that can do robust and efficient tracking of people in different rooms is still an open problem. There are already solutions in the state of the art for people tracking [3][4], however, coping with a massive amount of data and being capable of real-time processing, assessing resource vs. accuracy trade-offs [5], handling runtime adaptation through behavioral synthesis [6], or ensuring enough robustness to perform tracking of people in scenarios with occlusions, or multiple targets are still open challenges in the current literature.

As it can be seen, FitOptiVis represents a disruptive and extremely sound approach to reach this goal. However, it requires a different level of technology, much more "intelligent" than the current state of the art.

5.2 Innovations Introductions

There are many ways to approach the personal health market. In an ecosystem all approaches will be enrolled by different providers. This means lots of different companies and organizations are going to offer devices, applications or services on the personal health market, each from their own background and building on their own strength. This means that big and small, local and international companies from traditionally separated markets will meet each other on the personal health marketplace. We foresee all kinds of convergence between for instance sports, entertainment, lifestyle, consumer electronics, nutrition/food, telecommunication, trainers and coaches, business support services, medical devices, ICT, healthcare or finance in this market.

More and more aspects of medical care come in reach of individual citizens (monitoring, self-diagnosis) and medical care is going to concentrate more and more on the specialized and complex parts of care.

Consortia and dominant players are looking for serving a bigger part of the health continuum to keep customers engaged with their products and services. In combination with many different business models that are tried out the personal health market is highly volatile.

Many lists with barriers and drivers for healthcare innovation, eHealth or mHealth have been made. Below we have compiled several lists. There is a distinction made between general drivers and barriers for adaptation and those that can be used or overcome by healthcare provider organisations. In relation to the value network of stakeholders it should be noted that the drivers and barriers for each stakeholder should be analysed specifically for Fitoptivis.

Drivers: the main driver of revenue in the market will come from services and hardware, not from apps. Apps are a platform and will drive revenue from services they enable.

Smartphone user penetration will be the main driver for the mHealth uptake. The mHealth market will grow mainly in countries with high smartphone penetration and health expenditure. The world population continues to age, which results in a higher overall incidence of chronic diseases that need to be monitored in an on-going way.

The following are several general adoption drivers. Note that the drivers will not be valid for all stakeholders.

- Cost saving in healthcare. In most European countries the cost of healthcare are rising and there is a general tendency to counter that trend and to reduce the costs.
- Shortage of healthcare professionals. Due to the rising demand in healthcare and the aging workforce there are already shortages in certain areas of healthcare expertise. The predictions are that shortage will increase. Innovation could help decreasing the demand through prevention, early detection and patient empowerment. On the other side, innovation could increase the efficiency of healthcare delivery so professionals could handle a bigger caseload.
- Transition to extramural care and empowerment. The transition to extramural care is aiming to lower the housing cost in the healthcare budgets but is also

related to the fact that most people prefer to stay at their own home. Extramural care is not possible without more involvement of the patient or client so empowerment is closely related.

- Transition from curing diseases to prevention, healthy living and participation People can take on a bigger role in their health by living healthy and take some measures to prevent health risks. The focus on prevention and empowerment is also supported from a cost savings perspective.
- Economic and business opportunities. As the market analysis made clear, there is a huge potential market. These economic and business opportunities are driving the supply side of health innovations. The potential will only become real as the demand side will start to grow as well.

In parallel, the primary objectives driving healthcare provider organization's pursuit of a mHealth initiative:

- Organization brand and marketing. As healthcare becomes more market driven and competitive, many healthcare providers use mHealth initiatives to show that they are innovative. mHealth also provides new channels to create brand awareness.
- Cost savings. Healthcare providers hope to get cost savings from mHealth. Saving on more efficient workflow with mHealth needs good management on the outcomes. Many healthcare related savings will benefit other organizations in the value network.
- Customer/patient retention. Retaining patients is important for profitability of healthcare providers. This driver sometimes conflicts with the need to develop and implement open systems with lower switching costs.
- Increased customer/patient engagement. In order to generate real health value the patient or customer needs to stay engaged for a longer period of time. mHealth could help by making it easier for patients but also by making the services more personal.
- Improved health outcomes. Solid evidence for improved the health outcomes will increase the adoption for any intervention. In many cases mHealth is only changing the channel of healthcare service delivery and that will not improve the health outcomes dramatically.
- Pressure to compete. In general most of the drivers above can be seen as enablers to competition. With a more market driven healthcare system this pressure is felt by many healthcare providers. mHealth is also increasing the pressure to compete because new companies, for instance mobile operators are entering the healthcare market in a way that could be disruptive.

The following are several general adoption Barriers. Note that the drivers will not be valid for all stakeholders.

- The conservative culture barrier.
    - 27% of doctors and 26% of payers say an inherently conservative culture in healthcare is a leading barrier to mHealth. Yet this level of caution is understandable as innovations in healthcare could pose risks to human health as well.
    - The nature of many innovations will change the relations and responsibilities between professional and patient. This is always difficult to change if the trigger comes from technology.

- The size and complexity barrier
  - Healthcare is vast and fragmented, characterized by diffuse decision-making.
  - State control often means a lack of investment in technology. Governments need to become promoters of healthcare innovation.
- The regulation barrier
  - 45% of doctors believe outdated regulations from earlier technology are holding up mHealth.
  - Regulation will always be a barrier for innovation as innovation is bound to change the rules of the game
  - In several countries the reimbursement schemes do not motivate to innovate
  - Uncertainty about regulation does not help to make firm decisions. For instance, the medical device regulations in US and EU are taking a long time to become clear.

- Adoption barriers: Many mHealth solutions are aiming at elderly as their main target group. This is not the group of people that are most open for learning to work with new technology

The key challenges healthcare provider organizations face in achieving mHealth goals:

- Lack of funding. Innovation is mostly focused on medical technology or new interventions and ICT is focused on providing hard- and software to professionals to support the primary work process.
- No clear strategy and execution plan. Many healthcare providers are in the stage of acquiring experience and knowledge about mHealth by trying it out in projects or pilots. Most of the time mHealth is not yet part of the strategic plan. Lack of skill set in-house. As mHealth is not something that is part of the education in healthcare and most healthcare professionals are not technology focused there is still a lack of skills.
- Lack of leadership. Healthcare provider leaders have not been raised in a world with mobile technology. They also lack the skills and experience and do not get enough feedback about mHealth from their organizations.

5.3 Product User Requirements and Differentiation

In this context, the “tele-alarm” business has emerged. Specifically dealing with Habit Tracking Systems (HTS), it is mandatory to enable video processing with real-time performance. In such a context, one can leverage on multi-view (multi-camera) video processing systems that can do robust and efficient tracking of people in different rooms. There are already solutions in the state of the art for people tracking. However,

- coping with a massive amount of data and being capable of real-time processing, assessing resource vs. accuracy trade-offs,
- handling runtime adaptation through behavioral synthesis, and
- ensuring sufficiently robust tracking of people in scenarios with occlusions, or multiple targets are still open challenges in the current literature.

Some already available solutions are:

- NETATMO indoor security that includes also Face Recognition support, but it is not open [NET_WEB], it does not allow building an application with complete control of the technology.
- Just Checking [8], which does not provide activity detection, so it does not support and help users to modify their way of life, by establishing behavioral patterns and making objective performance measurements.

The FitOptiVis solution aims at taking this to the next level. So far, tele alarm systems do not enable such a high performance as “modifying the life style”. They can monitor, and generate alarms in case of a specific situation, but they are not so much oriented towards analyzing the behavioral pattern. FITOPIVIS can be considered a disruptive way to improve life quality, not just daily monitoring.

We want to do this by tracking with a multiple camera system by recognizing movements and different modules (medical, AR glasses, etc.) to get more information about the user's status. FitOptiVis represents a disruptive and sound approach to address the challenge of current technologies, smart sensor integration will allow the possibility of delivering more “intelligent” systems than those already available.

Actual Technology/Issues	FitOptVis Technology/Issues
Actual systems monitor and generate alarms for specific situations.	***Smart integration*** and ***components abstraction*** will lead to system generalization, moving the focus to behavioral patterns, in order to address life quality improvement rather than surveillance.
Actual systems cannot manage big amounts of data, real-time constraints and adaptation.	***Edge processing*** and ***reconfigurable workload distribution,*** built upon ***distributed communicating nodes***, will lead to ***real-time intelligent resource management***. .

Table 1: comparison between actual issues and proposed FitOptiVis technologies

5.4 Total Market Envisioned

FRAMINGHAM, Mass., September 4, 2018 – Growth continued in the global wearables market during the second quarter of 2018 (2Q18) as shipment volume reached 27.9 million units, up 5.5% from the previous year according to data from the International Data Corporation (IDC) Worldwide Quarterly Wearable Device Tracker [9]. The market experienced similar gains in dollar value, growing 8.3% year-over-year to $4.8 billion in 2Q18 fueled by the continued popularity of smartwatches with their high price tags.

Global eHealth market is expected to reach € 291.0 billion by 2022, according to a report by Grand View Research Inc15. The transition of the healthcare industry into digital healthcare system for management and analysis of patient health is expected to be the most vital driver of the market.

Increasing prevalence of chronic diseases, and technological advancements in this field are few impact rendering factors. Rising use of mobile technologies and internet along with increasing adoption for home care by patients is expected to propel market growth over the forecast period. The benefits encouraging higher demand include round the

clock care service, wider and faster access to patient information, reduction of administrative and medical errors, self-monitoring and management by patients and centralization of entire healthcare industry chain.

5.5 Commercial State-of-the-Art and Competitors Analysis

The active companies in the field are as follows:

- Tunstall: Tele-alarm business
- NETATMO: Cameras in-door for tracking events
- Siemens: Siemens Healthcare is one of the world's largest suppliers to the healthcare industry and a trendsetter in medical imaging, laboratory diagnostics, medical information technology and hearing aids.
- Philips: Has a strong position in medical technology as well as in home healthcare.
- GE: Is worldwide active in the fields of life sciences, medical diagnostics and healthcare IT.
- IBM: is specializing in healthcare IT. Latest introduction is: cognitive technology also known as Watson.
- Continua Health Alliance: Continua Health Alliance is a non-profit, open industry/organization of healthcare and technology companies joining together in collaboration to improve the quality of personal healthcare. The alliance is moving towards an interoperable eHealth ecosystem (Strübin2013)

5.6 Standardization Activities

RGB has been an active player in the CEN TC251 group for interoperability between medical devices. This activity for interoperability and standardization gave rise to ISO 11073 norm (connectivity of devices and definition of the interoperability procedures at device level). FitOptiVis results may turn out to be useful for this norm; therefore, RGB intends to study the potential use of ISO11073 norm within the Habit Tracking at Home scenario.

RGB is active in the Home Medical Equipment (HME) market, which is one of the most important segments of the healthcare market. This market is characterized by durable equipment that has to 1) withstand repeated use; 2) be appropriate for use in the home; and 3) be user friendly, since non-trained medical professional will operate it. RGB has pioneered since 1995 the telemedicine services as technology provider. In first place with the launch of the SAFE21 vital signs multi-parameter monitor for Home Care, the first CE marked monitor of its kind. Since then, RGB has kept at the edge of technology and has now a portfolio of tele-monitoring modules based on iphone interoperability and web services. The main clients over the years have been service oriented companies such as Tunstall, Telefonica Movistar, Indra, etc. Within FitOPtivitis RGB aims to link the tele-medicine service with the tele-assistance one. These have been typically isolated solutions. We expect to broaden our product portfolio including devices and web-based solutions for service oriented companies.

5.7 References

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6 3D Industrial Inspection Use case

This use case is led by ITI

6.1 Business Opportunities

Many manufacturing industries have developed mature processes to create their products from a well-known set of raw materials, machinery and tools, but there are still open problems in terms of quality control (QC). ITI's industrial inspection system (Zero Gravity 3D, briefly ZG3D) has the objective to improve the QC process applying innovative 3D computer vision techniques to capture, reconstruct and compare each produced part against a CAD model to obtain an Ok/Not Ok result over 100% of the production.

Figure 6: Comparison between actual produced part against CAD model

There is a leak in the current QC process that affects the whole industry in terms of costs and productivity. 3D QC scanners are too slow and therefore not suitable. Moreover, due the complexity and variety of shapes and categories, with conventional 3D scanners, automating the quality control process over 100% of the production becomes impractical. This kind of scanners need manipulation of each part under the scanner to obtain a full 3D reconstruction, this takes too much time and makes almost impossible to automate the process at an affordable cost.

In this use case, the ZG3D technology will be used to assess its feasibility in real industrial tasks and measure the positive impact in terms of productivity, capacity, and reduction of defects. Thanks to ZG3D, it is very easy to revise and control all the produced parts without either manual or mechanical handling. Each part is captured without visual occlusions, independently of its shape and category, and is compared against a reference model.

ZG3D system performs multiple complex and computationally costly operations: image acquisition, image pre-processing, image segmentation, 3D model construction and analysis of the built model. To increase the throughput rate, these operations are distributed. Specifically, image acquisition, pre-process, and segmentation are executed in low power execution boards placed next to the cameras. This architecture saves network load and improves the overall performance of the system.

Regarding end-users needs, QC operators should find an easy to use solution which improves the results of their work through a training process that must be clear, short and simple, and covering all features and functionalities of the solution.

6.2 Innovations Introductions

Our use case aims to enhance our ZG3D prototype by the introduction of an innovative component, the edge capturer.

Anyhow, it is worth noting that current solutions for 3D inspection could be classified into two categories:

- Active methods:
  - Fly time.
  - Structured light.
  - Modulated laser.
  - Conoscopic holography.
  - CT.
- Passive methods:
  - Stereoscopy.
  - Photometry.
  - Unfocussing.
  - Outlines (Silhouette).

With this new technology based on 3D computer vision with an innovative approach. It is very easy to revise and control all the produced parts without manual nor mechanical handling.

Each part is captured without visual occlusions, independently of its shape and category, and is compared with a cad model (multiple cad models from different categories or references can be loaded in the system). Our system analyses geometric dimensions and tolerances (GD&T), also volume and surface and takes the decision to accept or reject the part, in real time.

Whit this new approach, we can also detect mix of parts from different references inside a production batch avoiding the need of screening tasks when a mix is detected in final customer.

Our exploitation plan includes a set of experiments with manufacturing companies that are being carried out to assess the feasibility of ZG3D for different real tasks provided by the industrial partners. The successful results of these experiments will allow the participating companies to include an innovative inspection stage into their lines that will be useful to ensure the quality of the whole production, i.e. 100% of part inspection. In other words, we want to demonstrate that our system is able to improve this task and contribute to increase the performance and productivity of the target industry.

6.3 Product User Requirements and Differentiation

Most companies apply sampling methodologies for its quality control process, so only a small part of the production is really controlled using lab instruments like gauges, profile projectors (analog or digital), 2D and 3D computer vision and others. But all of them need human interaction and are slow processes that impact the process and makes it impossible to automate for the whole production.

On the other hand, sometimes manufacturers are bound to manual inspect the whole production. This is highly time consuming and is made by hand using gauges and poka-yokes, definitely increasing the production costs.

ZG3D will be used to check the full production of several production references, mainly those that are under risk of penalty if a wrong part is delivered to the end customer. This will reduce the economic exposure against customer claims.

Moreover, it will be an important reduction of the lead times to customer for each order. We can consider that our system works in real time (throughput will be around one part classified and inspected per second, or even more), so there will be no significant delay between production and availability of each order to be served to customer.

By now, after a complete order is produced (or a part if it is too big to be stored in an intermediate stock) QC team needs to check and classify manually each part and this is not efficient. As we expect to inspect and classify in real time, we can reduce lead times, approaching to a just in time model of production. This will open an opportunity to our partners to accept and serve more orders and more efficiently with less risk. Moreover, the main advantages provided by ZG3D are described below:

- Currently, the quality control phase in the production chain is performed by sampling and requires some manipulation of each piece to be checked. This fact impacts negatively as industrial inspection is a field that requires fast and accurate systems that do not slow down the manufacturing process. Contrary to that, ZG3D increases the speed and accuracy of the QC process.
- Critical industries such as the automotive require the inspection of the whole production. Our technology is compliant with the zero defects requirement without the need for manual processes and so, without increasing the cost of the final product.
- ZG3D minimizes errors in quality control processes which are introduced by manual inspection. Human errors due to the long verification times and fatigue produce great inefficiencies and has an impact on the final cost of the product.
- Our product provides traceability and many key indicators can be used to track and detect defects or deviations in production, reducing the discarding of parts and minimizing the costs of non-quality.
- ZG3D is a highly scalable system that allows the control of a highly diverse range of different types and sizes of parts, without the need for reconfiguration or custom adaptations.
- The return on investment is very fast and does not negatively impact the final price of the product. Because of this, cost savings are a consequence of ZG3D automatic quality control.

In addition to these features, the solution should accomplish the following users/customers requirements:

- The UI must be easy to use for a trained factory operator.
- Real time monitoring of parts must not affect the system’s performance
- The system must be versatile so it can analyze parts with a wide variety of shapes
- The system must be able to differentiate several types of parts and sort them.

- The time elapsed since a capture is taken until the system response should be below 5 seconds.

6.4 Total Market Envisioned

Several reports [4][5] conclude that the Quality Control Market will grow constantly along the next years. These estimations assume to surpass $44,212.1Million by 2021 growing at an estimated rate of more than 6.22% during the period from 2018 to 2021 and mainly in major sectors like automotive.

The aim of our use case is to demonstrate that with our system we will obtain a considerable increase of productivity. The first main target is spring manufacturers market. Our market studies and market search have shown that spring manufacturers face with similar issues in terms of QC as well as in pressure on selling prices and a strong push for shorter delivery time. Manufacturers are focused mainly on fighting these issues working on these principles: Innovation, technology and lean operations. Our system has been designed based on these principles.

Spring manufacturers market is present widely around the world. They are suppliers of the most important industrial sectors:

- Automotive
- Aircraft industry
- Electrical industry
- Machine building
- and others

Almost every spring manufacturer is supplier of one or more of these sectors and are potential customers for our new system.

Our first target markets are (approximated data):

- Spain: around 114 manufacturers and 117 million€ of turnover
- Germany: around 170 manufacturers and 2105 million € of turnover
- USA: around 288 manufacturers and 2650 million € of turnover

In order to check our technology, ITI has established a partnership with Muelles Castellano S.A. which manufactures of springs, strip forms and stamped parts for the automotive sector. Our partner dedicates three specialized technicians, full time, to the QC task. By the automation of the QC process, we expect to reduce the work hours dedicated to this task from the actual 5,4K hours/year to less than 1,5K hours/year. This represents a direct reduction in hours of around 72%. That, is we can expect an increase in productivity of around 3,5 times the current one.

If we put these figures in the Productivity formula, and considering:

P =productivity

G = Goods (outputs, parts produced)

I = Inputs (labour hours)

Before our experiment P=G/I

After our experiment P=G/(I*0,28) = (G/I) * 3,57

As said before, theoretically we can expect an increase in productivity of around 3,5 times the current one.

6.5 Commercial State-of-the-Art and Competitors Analysis

Industrial computed tomography scanning is any computer-aided tomographic process, usually x-ray, that uses irradiation to produce three-dimensional representations of the scanned object both externally and internally.

The "Avizo Inspect" [1] solution for industrial inspection offers a 3D analysis and inspection software for dimensional metrology, based on digital object captures performed with a computed tomography acquisition device. The precision of the acquisition is quite good, so the objects analyzed with this system can be accurately checked to verify that they meet the tolerances defined for every required measure. However, objects cannot be fed at high speed into the acquisition device. Moreover, only the cost of such an acquisition device can be excessively high to achieve a cost-effective product.

Drawbacks versus “ZG3D”:

- Throughput.
- Mechanical manipulation.
- Cost.

Structured light 3D scanners project a pattern of light on the subject and look at the deformation of the pattern on the subject. The pattern is projected onto the subject using either an LCD projector or other stable light source. A camera, offset slightly from the pattern projector, looks at the shape of the pattern and calculates the distance of every point in the field of view.

VisionMaster [2] provides a solution based on structured light scanning to automatically recognize and measure solder.

Drawbacks versus “ZG3D”:

- Throughput.
- Mechanical manipulation.
- Cost.

ATOS [3] is an optical 3D scanner based on fringe projection, delivering accurate and traceable 3D coordinates. The "ATOS Core for 3D scanning and Inspection" offers measurement of small to medium-sized components such as ceramic cores, cast and plastic parts. The 3D scanner is used in development, quality assurance and production

to reduce time and costs. Main applications are 3D inspection, reverse engineering and rapid manufacturing.

Drawbacks versus “ZG3D”:

- Throughput.
- Mechanical manipulation.
- Uncomplete reconstruction.

6.6 Standardization Activities

The aim of our product is to standardize the QC process in manufacturing to reach a zero defects state. In order to achieve this, ITI is executing standardization activities in terms of device patents. As an example of this, we will detail below two patents obtained in the last year.

The first one is a device and a method which permits the acquisition and subsequent reconstruction of objects with volume throughout the total external surface (patent EP2511653). It has a particular mode of acquisition on the free fall object in such a way that there is no support surface which prevents acquisition of the surface which would be hidden by said support. The invention is also characterized by special modes of distribution of the cameras which optimize image capturing and provide useful information in the subsequent reconstruction of the volume through computer means.

The second one is also a device for the acquisition and reconstruction of objects by visual inspection (patent EP13925EP00). This alternative is characterized by the use of an actuator used as launcher and configured so that the object is positioned at the point of image capture at speed either zero or very close to zero to improve the resolution of each image without blurring due to motion, even with exposure times relatively long..

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7 Road traffic surveillance Use case

This use case is led by CAMEA

7.1 Business Opportunities

Users and customers in the area of traffic monitoring systems are mostly municipalities and police. There is emphasis put on the cost of the system but also low power consumption is important nowadays as systems can be then installed at any place that is the most suitable for the application. Reliability is also very important to make the system trustworthy. Least but not last flexibility of the system and ability of interconnection with other systems is also very important criterion.

7.2 Innovations Introductions

In case of CAMEA, camera with integrated LP (Licence Plate) recognition allows to simplify traffic monitoring systems. Complexity is reduced, input power is lowered as well and the final system can be potentially cheaper. Increased reliability is expected as well thanks to migration of complex and computationally demanding algorithms into HW and thus reduction of SW processing in universal PC (used for processing at the most of sites at the moment).

7.3 Product User Requirements and Differentiation

A novel camera device should have an ability of vehicle detection, LP recognition (for the whole EU region at least), be able assign country of registration (important for querying in registry of vehicles). This should reliably work for all vehicles in all road lanes - at least on a speedway with two lanes or or better including emergency lane. At the same time, camera should have such image resolution and quality that LP is clearly visible and readable including the whole vehicle and its driver's face. Camera platform shall allow fixed installation or even mobile onboard application. The outputs of camera device should be following:

- compressed video stream (using state-of-the-art codec) for CCTV,
- detection results - data packages containing images including LP, time, location and so on.

From technical point of view, the camera should work 24/7 and should have low power consumption (e.g. enabling solar power operation - especially in countries with less developed infrastructure e.g. Africa, South America or Russia). Crucial is also extended temperature range for device operation (at least -40 to +55°C) same as the rest of CAMEA system's components. As well, important is IR flash syncing and time synchronization.

From the competitive advantage point of view, the unique and required property is ability of reliable detection in low light conditions (e.g. during the night) and at high speed at the same time. Most of competitors offer systems that work in the night for speeds 100-150 kph maximum. However, certified systems have to work for much higher speed (up to 250 kph). If this requirement is not met, such camera can't be considered as universal

device that could be used for cities and highways with the same configuration. Moreover, such system then allows unwanted and dangerous speeding.

Generally, potential outages are not acceptable but planned service shutdown can be accepted (e.g. quarterly). Requirement of high reliability is defined by safety role of a camera that should not be interrupted. As well, physical service work is often not easily doable (e.g. due to installation in highway tunnel).

7.4 Total Market Envisioned

Significant development of the market in the traffic enforcement area is expected. This would be a consequence of increasing intensity of traffic, slow process of construction of bypasses and highways and thus unavoidable intensive traffic flow through cities and built-up areas. This brings more restrictions in form of “no overtaking” or reduction of speed limit. At the same time, more pedestrian crossings with traffic lights are being built.

In connection with above mentioned, trend of increasing drivers’ aggressivity and breaking traffic rules is apparent. These facts have bad influence on safety and life environment in cities and towns. Consequences are increased danger for pedestrians, increased dust pollution and air pollution.

One of possible solutions of these problems are automated traffic enforcement systems. Such systems are mostly installed well visible and driver is informed about them in advance by traffic sign or satnav. In praxis, it has been proven that such system are not able to completely prevent traffic offences but reduction is significant. For example, in case of speeding, usually more than 50% of traffic intensity goes over speed limit. After installation, this percentage is reduced 20 to 50 times. Those fact are well known and proven and thus one can expect (and the inquiries indicates) increasing demand from cities for traffic enforcement systems.

Regarding markets available, EU market is quite saturated and thus CAMEA is looking for partners that are able to supply system cooperating with our camera systems especially in location of Western Europe. Our position will be stronger with newly developed camera. In the world, CAMEA is oriented mostly on developing markets in Southern America, Africa and Russia (where the competitors are at advanced level). Improving technical parameters and reducing prices are key aspects. Currently, the most sold system using CAMEA’s camera devices is WIM system and popularity of section speed system is also increasing.

7.5 Commercial state-of-the-art and competitors analysis

The main CAMEA’s competitors in the field of complex traffic monitoring systems are:

- GEMOS CZ spol. s r.o. [1] - competitive traffic monitoring systems (red-light enforcement, section speed control and preparing spot speed measurement)
- CROSS Zlín [2] - competitive high speed WIM (Weigh-In-Motion) systems
- RAMET a.s. - competitive systems for spot speed measurement using radars

There are many companies developing general video-based systems that can serve as red light enforcement system or section speed check system. In these areas,

progressive launch of systems on the market is expected. Currently, known competitors are:

- NITTA Systems
- Colsys s.r.o.
- Eltodo a.s.

There are also manufacturers (as big players) that already has surveillance cameras with embedded detection and LP recognition:

- SAMSUNG
- Hikvision
- Dahua
- AHR
- Avtouragan (Russia)
- Vokord (Russia).

Some of them already offers traffic enforcement systems abroad.

7.6 References

[1] www.gemos.cz
[2] www.cross.cz

8 Multi Source Streaming Composition Use case

This use case is led by Phylips

8.1 Business Opportunities

In a clinical operating room images from several image sources (i.e. Xray, Echo or Heamo equipment) used to be displayed on separate monitors each with their own characteristics and little means to adapt the information to the user's wishes:

Figure 7: An example in an operation room

So there is a growing demand on more flexible solutions which means that in more modern systems are combined on a single large screen.

Figure 8: Operation room

The layout of this screen is not fixed but changes depending on the kind of procedure and physicians' preferences. Today those images are simply scaled to the requested size and then composited onto the screen. As a result, graphics can become distorted and user interfaces can become in-operable. Furthermore, the compositor function is always fed with the full image information of all sources, leading to high bandwidth requirements and high power demands.

8.2 Innovations Introductions

The core of the product is a composition device that is able to acquire video data of several independent sources on a large screen. This technique is not very new, but is usually implemented in a very straight-forward way with a number of drawbacks:

- High power requirements
- High bandwidth requirements
- High latency

The latter is not always important in all applications, but in medical procedures where visual feedback of movements is required, it becomes crucial and should be kept as low as possible. Other applications where multiple images are presented on a single screen involve for example:

- Traffic monitoring
- Surveillance

In those applications bandwidth- and power-reduction will help cutting cost and increasing usability of (existing) network infrastructure.

8.3 Product User Requirements and Differentiation

The FitOptiVis results will be used in the Philips Azurion [1] family of X-ray systems which is the next generation image-guided therapy platform that allows to easily and confidently perform procedures with a unique user experience, helping to optimise the lab performance to provide superior care. Azurion has been developed over a number of years in close collaboration with our clinical partners to ensure workflow solutions that meet the continuing demands of the interventional lab. Versatile low-latency image display is a key feature for the success of this system.

8.4 Total Market Envisioned

Philips Healthcare is a large industrial company active at the international level. Within FitOptiVis, Philips will further develop its interventional X-Ray system.

The size of the medical equipment market hits 35 Billion $ in 2019 and is expected to grow to over 45 Billion $ annually in 2024, out of which ca. 5 Billion $ is attributed to interventional X-Ray.

Philips is one of the major players in the market for interventional X-Ray with a market share of 25%-30%.

8.5 Commercial state-of-the-art and competitors analysis

State of art solutions of the major competitors currently use frame grabber devices to input the image stream from the image source into a PC where a graphics card takes care of display composition and rendering. Apart from the high power requirements, this technique also introduces tens of milliseconds latency in the image stream. This extra latency hampers correct optical feedback for doctors performing precision operations so this should be avoided as much as possible.

Products of the three largest companies in interventional X-ray currently on the market:

- Philips: Philips FlexVision [2]
- Siemens: ARTIS large Display [3]
- GE: Large Display Monitor (LDM) option, part of IGS-520 system [4]

8.6 References

[1] http://www.usa.philips.com/healthcare/resources/landing/azurion
[2] http://www.usa.philips.com/healthcare/product/HCOPT15/flexvision-xl-display-screen
[3] https://www.healthcare.siemens.com/angio/options-and-upgrades/components-and-options/artis-large-display
[4] https://www.gehealthcare.com/en/products/interventional-image-guided-systems/igs-for-electrophysiology/innova-igs-520

9 Sustainable safe MRI Use case

This use case is led by Philips-MR

9.1 Business Opportunities

Magnetic Resonance Imaging (MRI) is a medical non-invasive imaging technique which does not require ionizing radiation. It is used amongst others for diagnosis, treatment guidance and treatment response monitoring. Since it is particularly strong in imaging soft tissue it is the golden standard in brain imaging. The technique is based on Nuclear Magnetic Resonance, a physical phenomenon in which nuclei in a strong static magnetic field are responding to specific magnetic field variations. This response strongly depends on aspects like tissue properties and moving matter, which allows MRI equipment to produce a vast variation of image types with e.g. specific tissue contrast or sensitivity to blood flow.

Over the years, since the introduction of commercial MRI equipment in the beginning of the 1980s, the quality and information content of the produced images has been improved in a steady pace. Partly this can be contributed to the availability of better hardware, such as the ability to create the required magnetic field variations faster. However, this came with undesirable side effects. Firstly, these faster magnetic field variations, due to interaction with the human body or between system components, can produce physiological stress such as tissue heating, stimulation of peripheral nerves and acoustic noise. Secondly, the energy required to produce an image also has been increased, leading to increased environmental burden.

9.2 Innovations Introductions

The Use Case is related to allowing the user of the system to determine the optimal balance between physiologic stresses in patients of several kinds, energy consumption and the resulting quality of the image.

Safety limits for the kind of physiological stresses typical for MRI are covered by an international standard [1]. Results of Fitoptivis will be shared with this standard.

Philips expects that the business proposition enabled by FitOptiVis technology, causes a significant growth of at least 10% of their market share in developing countries with an unsaturated market, mainly at the cost of non-European competitors which will not be able to implement this technology rapidly in their strategy as fast follower. This has a positive impact on the export figures of Europe. In addition, we plan to sell FitOptiVis enabled upgrades, based on FitOptiVis improvements with respect to system modelling, to Philips systems to be deployed over the coming years. In addition to a better competitive position in the replacement market, this leads to an additional income of roughly MEuro 125 from saturated markets. End users in hospitals will use the improved MRI equipment.

9.3 Product User Requirements and Differentiation

The envisioned product is a new variant of a Philips MRI product, adapted to the specific needs of this use case. It will include, amongst other:

- Components or devices, known as ‘gradient coil’ and ‘body coil’, which are designed for increased efficiency. This is expected to result in reduced physiological stress, energy consumption heat dissipation and acoustic noise. Prototypes of these components will be designed and evaluated as part of the use case. Also delivered with these physical devices, and which is regarded as part of the device, is a model description of the physiological stresses that can be caused by these devices. Note that this model description is relevant for FitOptiVis.
- A module, accessible to the end user via a user interface, that controls the various kinds of physiological stresses, energy consumption and image quality. This module implements the multi-objective optimization, part of the Fitoptivis objectives.

9.4 Total Market Envisioned

Sustainability is at the core of the vision of Philips. Quoting Frans van Houten, the CEO of Philips: "At Philips, we fully embrace sustainability because of the benefits for societies, and because we believe that it is a driver for economic growth. That’s why we have sustainability incorporated in our company strategy."

On the sidelines of the World Economic Forum annual meeting in Davos, Switzerland in January 2018, Frans van Houten won the Fortune Award for Circular Economy Leadership for his pursuit of a circular economy-development without waste [2]. Also Philips ranked #2 in the 2018 Dow Jones Sustainability Index [3].

In view of the successful sustainability strategy of Philips, an MRI product that allows the user to control the energy consumption explicitly will fulfill market need.

9.5 Commercial State-of-the-Art and Competitors Analysis

The MRI market is characterized by a few players: Canon (Japan), GE Healthcare (US), Hitachi (Japan), Philips (the Netherlands), Samsung (Korea), Siemens Healthineers (Germany) and United Imaging (China).

Energy consumption of an MRI system is not yet an important part of the product data. COCIR, the European Trade Association representing the medical imaging, radiotherapy, health ICT and electromedical industries, has defined a standard measurement method to characterize the energy consumption of an MRI system. The data is intended for potential customers to compare products At the time being, publication of this information is still voluntary. Philips references COCIR when publishing the average power consumption during scanning in the Philips MRI product data.

In the state-of-the-art no product offers the user the ability to control the energy consumption explicitly.

9.6 Standardization Activities

Results of Fitoptivis will be shared with standardization bodies IEC6-60601-2-33 International standard, Medical electrical equipment [1].

9.7 References

[1] IEC6-60601-2-33 International standard: Medical electrical equipment – Part 2-33: Particular requirements for the safety of magnetic resonance equipment for medical diagnosis
[2] http://fortune.com/2018/01/25/philips-ceo-frans-van-houten-sustainability/
[3] https://www.duurzaam-ondernemen.nl/philips-ranks-2-in-the-2018-dow-jones-sustainability-index/

10 Robot Calibration Use case

This use case is led by REX Controls

10.1 Business Opportunities

Robots, robotic arms or manipulators with replaceable links or end effectors or robots with manufacturing inaccuracies need to calibrate. Especially the first mentioned need periodical recalibration after each geometry change. System for fast and automated calibration without the need to mechanically connect a measurement device can therefore significantly improve the calibration process. Fast, accurate and automated calibration of such systems significantly reduces the maintenance costs and allows a single worker to manage more robots.

10.2 Innovations Introductions

The robot calibration systems consist of 2 main components – point tracker that can localize POIs in 3D world coordinate system and mathematical apparatus that estimates robot parameters from parametrical robot model and point cloud acquired during the robot calibration movements. Alternatives both for point tracking and robot calibration apparatus are available (see paragraph 5). However, the price level of the professional solutions is very high. REX targets at applications where the price matters but the precision is still of high concern. The precision of the suggested point localization method cannot be compared to the laser interferometric trackers. However, the achieved precision is still sufficient for many applications while the price is more than 10-times lower.

Therefore, it makes sense to individually address both of the mentioned components and especially the connection between them to present easy manageable, comprehensive and fully integrated solution for robot calibration.

10.3 Product User Requirements and Differentiation

The envisioned product should be based on common industrial cameras, remotely controlled active LED markers and an industrial controller or PC. The 3D point localization algorithms will be implemented as functional blocks in the REX real time control system. Later on it is planned to move them into “hardware” and implement them as IP blocks inside a smart camera. The calibration algorithms will be implemented as functional blocks in the REX real time control system. The binding between point localization and robot calibration algorithms will be implemented via standard REX tools – block schemas and scripting.

The solution targets at middle-level applications where it is not possible to afford high-tech calibration methods but still precision is of a high concern. It is estimated that manufacturing costs of a system capable to localize points with 0.1 mm accuracy in working area of 1x1x1m and corresponding calibration precision will be around 4000,- EUR.

REX plans to offer not only the full robot calibration suite but also the point tracking subsystem which may have even bigger economic potential than the full robot calibrator.

Finally, it is necessary to note that the expected result of this use case is a prototype, TRL 5 – 6. It is not expected that the product will be finalized during the FitOptiVis project. First after extensive testing of the prototype in real environment it will be evaluated its potential and in case of success it will be turned into real product.

10.4 Commercial State-of-the-Art and Competitors Analysis

As stated above, the robot calibration systems consist of 2 main components – point tracker that can localize POIs in 3D world coordinate system and mathematical apparatus that estimates robot parameters from point cloud acquired during the calibration moves. Usually, the 2 components are sold separately as the trackers can be used in many applications and robot calibration is only one of these cases. Some companies providing calibration software offer also integration of their software with commercially available trackers. The supported trackers are usually high-end laser trackers implicating high price of the end solution.

Point trackers

The currently available point trackers can be divided into 2 groups based on the principle used to obtain point 3D coordinates - mechanical and non-contact.

- Mechanical trackers. Mechanical trackers use a thin wire or rope wound on a spool whose angular position is measured by potentiometer or incremental/absolute angular sensors. The mechanism allows to measure exact distance from a reference point. Using multiple wires and reference points (usually 3) it is possible to determine 3D point position. This kind of measurement is very accurate, however mounting of a special mechanical device to the robot before each calibration process is very inconvenient and time consuming, especially for big robots. On the other hand, for small robots the mechanics of the measurement device may influence the position of the measured parts (as the measurement force is not zero) and thus influences the calibration results. As an example DynaCal from Dynalog [1] can be given. Another big group – CMM tactile arms - uses similar angular sensors housed in freely adjustable joints between its arm segments. Returned are 6D coordinates (position and orientation) of a spherical end probe. State-of-the-art representative is for example Absolute Arm 7-Axis from Hexagon [2]. These machines can be used for object shape reconstruction but are less suitable for dynamic point tracking.
- Non-contact. Non-contact tracking methods are increasingly gaining popularity and constantly replacing trackers based on mechanical principles. The progress in development of hardware and computer vision algorithms allows construct more sophisticated devices at reasonable price. Today's non-contact systems can be classified into two categories - visual tracking of markers based on stereovision or laser beam based trackers. Stereovision tracking systems use two or more cameras to get several projections of the scene. From known position of the observing cameras or reference points in the scene it is possible to determine the 3D location of the POIs (points of interest). The markers can be either passive with highly reflective surface (Vicon, [3]) or active, using LEDs. In both mentioned cases it is necessary to solve the point registration problem –

i.e. decide, which points correspond in images from different cameras and from different time. The registration problem is quite challenging and prone to errors. Some systems using active markers try to bypass it by using technology that can distinguish individual markers. There exist either time-synchronized LED markers that are connected using wires to a controller (Qualisys, [4]), or LED markers distinguished by light wavelength, i.e. LED color (Biosense Medical, [5]). The proposed solution using wirelessly synchronized active LED markers has not been utilized yet. Laser trackers can work on several various principles. The most precious and expensive solutions work on interferometric principle. The device emits sweeping laser beam onto the scene and observes the reflected beam with interferometer (Leica Absolute Tracker AT960, [6]). Other systems use parallax to observe position of the laser beam in scene with camera with known relative position to the laser emitter. At last, quite unique solution is used in the RCbenchmark Otus tracker [7], where sensors in the measurement head observe the emitted laser beam, respectively the time, when they detect the sweeping laser beam touching the sensor.

Robot calibration software. The robot manufacturers usually deliver proprietary solutions for their robots or through their distributors sell the calibration as a service. A few third-party companies offer calibration platforms. To the state-of-the-art platforms belongs the RoboDK platform [8]. The programming API together with the possibility to control wide range of industrial robots (KUKA, Fanuc, Yaskawa, ABB, Stäubli, Comau, UR, …) makes it very flexible and competitive product.

10.5 Standardization Activities

REX is an SME with very limited power to introduce and enforce new standards. Instead, the solution is planned to stick to existing industrial standards:

- For the description of calibration moves the XML file format is used.
- To perform robot movements according to the user description are provided drivers capable to handle many industrial communication protocols and/or control robots of wide-spread robot manufacturers.
- 3D coordinates of the markers used for calibration are stored in commonly used point cloud file formats.

10.6 References

[1] http://www.dynalog-us.com/dynalogmainsite_030.htm
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[5] https://biosensemedical.com/active-marker-motion-capture/
[6] https://www.hexagonmi.com/products/laser-tracker-systems/leica-absolute-tracker-at960
[7] https://www.rcbenchmark.com/pages/otus-tracker
[8] https://robodk.com/robot-calibration

11 Surveillance Smart-Grid critical infrastructures Use case

This use case is led by 7SOLS

11.1 Business Opportunities

Critical Infrastructure functions are often technologically and operationally interconnected. In the case of energy distribution networks, disruptions and failures are a real concern. Significant efforts are being dedicated to develop new technologies, processes and methods to reduce the system vulnerabilities. Many of them are based on smart-grid awareness techniques and they primary focus on health and security aspects of the supply network. Given the large extension area where smart-grid operates, solutions to improve the levels of efficiency and security of these facilities are needed. Smart surveillance provides an adequate level of protection by combining the information from video surveillance in a multi-view approach, with critical control data and redundancy techniques.

Distributed infrastructures have triggered security concern related to physical attacks or natural disasters among others. Thus, prevention represents a security challenge. In addition the tasks of monitoring and control over each element and process involved on this type of infrastructure it is also of utmost importance. Smart security and monitoring-control. Smart security practices based on high-performance smart components for image processing pipelines able to estimate motion and related parameters as depth cues, or background-foreground subtraction are promising to address these issues.

In an ecosystem where control and video data coexist, determinism plays a central role. Real-time scheduling methods for distributed and heterogeneous systems are needed to address this specific issue. Most Ethernet-based solutions, although their low cost and high-speeds features, are known to be unsuitable for safety-critical applications. Ensuring bounded latencies for the communications and reserving part of the bandwidth is expected to improve the communications in the smart grid respect to performance, availability and synchronization.

Time-Sensitive Networks, TSN refers to a suite of IEEE standards defining ultra-deterministic networking operation to provide traffic control over Ethernet. TSN traffic streams are scheduled to meet stringent performance characteristics (zero-packet loss), traffic differentiation (best-effort and critical traffic) and prioritization. For each priority different grades of bounded latency delivery are defined. The traffic congestion can be monitored in each node of the network and a common notion of time can be achieved through clock synchronization (PTP).

On the other hand, network infrastructures of critical applications should be operational 24 hours a day, 365 days a year and redundancy protocols are needed to ensure the network's ability to reconfigure in the event of failure. High-availability Seamless Redundancy (HSR), based on the standard "IEC 62439-3" that offers seamless failover against failure and higher performance and synchronization is the most reliable protocol since it provides 'zero reconfiguration time' ain case of a single failure through a mechanism that consists of duplicating and sending all incoming data packets simultaneously over different directions in a ring topology.

Situational awareness is a key element of the network security. Most present day multicamera solutions that detect and track potential risks in the surroundings of critical infrastructures are not mature, although some partial solution has been proposed [1][2]. The active selection of the cameras to perform tracking in real-time, according the best view of the target is a need as well as the monitoring and tracking of processes Systems to select the best camera and process features only from the cameras, an able to transmit e.g. low resolution data from the other cameras as best effort are an open issue.

11.2 Innovations Introductions

Smart-grid as mostly safety-critical systems must present real-time features. The correctness of the processes taking place as well as the validity of the different solutions depends on the time instance at which they are produced. Complementary solutions based on failure prevention techniques are required to mitigate the impact of the failure. The use case will deal with these issues to guarantee reliable communications, in a zero-packet loss scheme and with zero-reconfiguration time in case of in the case of failure. Prevention will be addressed through multi-view image processing. The hybrid solution that is being developed is envisioned to be widely used in areas with mixed-criticality applications via multiple traffics as Industry 4.0 and has the potential to transform global energy, oil and petrochemical sectors.

Industry 4.0 is based on the massive interconnection of Cyber Physical Systems combined with a Big Data analysis, has underlined the need of real-time reliable and secure communications. Industry 4.0 involves the transition to Ethernet with minimal impact on the interoperability among different devices and with guaranteed latency. Nowadays, there is a strong consensus on the TSN solution being able to fulfill the strictest requirements of industry 4.0 through a number of mechanisms that guarantee an upper bound value for latency (as well as fixed bandwidth) and that critical frames are given higher priority for their transmission over best effort frames.

The first step for developing an appropriate exploitation strategy is to identify the exploitable results derived from the use case. Potential stakeholders whose infrastructures provide a scenario where the solution can be probed are the most relevant. After this firt-step, the solution can be evolved into long-term market offerings depending on partners individual interests. However, given the complex requirements of industrial applications, the introduction of this hybrid technology is not straightforward and it is foreseen that it will involve significant development efforts to adapt to changing requirement.

11.3 Product User Requirements and Differentiation

The following requirements and specification features derive from applications requiring secure and reliable communications (as industry 4.0):

Mixed-criticality traffic. TSN is suitable for applications of different safety-criticality levels. TSN address the problem of routing for different traffic assignment in order to make the traffic meet pre-defined QoS with bounded latency.

Determinism is key to enable larger and faster networks. The convergence of different classes of traffic in multiple applications in one network requires a common notion of time only provided by deterministic features.

Traffic scheduling to avoid the interference of unscheduled messages impose on each other. By using global notion of time, the schedule is created for message paths across multiple network components.

Bounded latency is crucial in applications with strict deterministic requirement. It is provided by accurate synchronization over the network.

Robust tracking of people performed in real time, handling occlusions and ensuring that multiple targets can be followed.

Active mechanisms for tracking targets, using different cameras to follow the targets in real-time, selecting the camera that has the best view.

Redundancy communications provided by HSR (High-availability Seamless Redundancy) to minimize the risk of failure in the network communication between elements of monitoring and elements of control, and thus be able to avoid a failure in the behavior of the critical infrastructure.

11.4 Total Market Envisioned

The most interesting potential markets for this type of product is the industry 4.0. Europe is projected to account for more than a third of global Industry 4.0 investments by 2020.

The market is expected to grow at an impressive average annual growth rate of 22%. Reaching a value of €287 billion in 2020, Industry 4.0 is Europe's largest IoT market [3].

Regarding the industrial sector, it comprises more than 2 million manufacturing companies and is responsible for over 33 million jobs and over 80 % of the European exports [4]. Moreover, it represents the 60 % of productivity grow of the Europe [5]. In addition, recent studies have estimated that the new horizons for industry can add more than 100 billion of annual revenue to the European economy in the next four years [5].

11.5 Commercial State-of-the-Art and Competitors Analysis

Industry 4.0 is expected to improve aspects in the manufacturing related to the speed, security, productivity and maintenance.

The European industry 4.0 is led by global companies as Siemens, SAP, Microsoft, HP, Intel, TI, Alphabet-Google, Samsung and IBM [4] who have invested billions of dollars in Industry 4.0 products R&D, M&A and Commercialization & Internal Use. However, the global economy is being transformed by this forth industrial revolution and business processes as supply, manufacturing, maintenance, delivery and customer service are immersed in a process of continual transformation with a view to consolidating this new paradigm and new forms of collaboration between companies, both nationally and globally are foreseen [4].

It is important to take into account that globalization has deteriorate the European contribution of industry, and the EU target for manufacturing activities should represent 20% of total value-added in the EU by 2020 [5].In response, EU public and private sectors are investing billions in Industry 4.0 solutions each year to increase the European industrial network and help to revert the situation.

11.6 Standardization Activities

The digital transformation brings new technologies and solutions business models and requires supportive regulations. Digital transformation brings new technologies, services, or business models. It thus requires a clear and supportive regulatory environment. [6].

Regarding TSN, it is foreseen to be a fully IEEE standardized solution, as opposed to other proprietary Industrial Ethernet alternatives (e.g. EtherCAT or PROFINET). Looking at the standardization activities, the most relevant actions are being carried out within the IEEE 802.1 TSN task group. Most of the activities focus on QoS, synchronization, reliability and determinism, as response to the strict requirement of industrial applications. Since TSN features are defined as amendments to the main IEEE 802.1Q [7] standard probably major vendors will support it.

11.7 References

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12 Space Use case

This use case is led by Thales Alenia Space España

12.1 Business Opportunities

The space sector is in turmoil, the strong entrance of mega constellations and other new elements in the market are changing the rules of the game. Reduced mass and cost as well as short time to market are key elements on the new generation of spacecraft, ranging from Telecommunication, Science and Earth Observation platforms, whatever their size. With the increase in performance on the global market and the generalization of small platforms, many new challenges are emerging which are going beyond the physical limits of the current systems.

To tackle this limit and reach performances beyond the current state-of-the-art, a new approach is needed with new materials, designs and manufacturing techniques that deliver a performance in coherence with the rest of main elements of the spacecraft. Thales Alenia Space Spain has a long track in the development, manufacturing and delivery of high performance Video Processing units and is now targeting the definition of the next generation of video processors that will constitute the core of the next wave of earth observation and robotic planetary exploration missions. The challenge is to develop flexible high capacity video processing platforms at a fraction of the current cost. Furthermore, the short development times available for the new mission request that the Video processing units shall be able to adapt quickly to evolutions in the environment of the satellite and on the video processing algorithms to be implemented.

12.2 Innovations Introductions

The product target for FitOptiVis developments is a reconfigurable video processor based on an MPSoC built inside reconfigurable FPGAs. This unit will have to deliver as much video processing capacity as current units at a fraction of the cost and the mass and shall include dynamic video processing.

Through dynamic video processing reconfiguration, the reconfigurable video processor will be able to adapt its performances to changes in the mission needs and in its environment. The new FitOptiVis enabled Video processor shall be able to adapt as automatically as possible to the following scenarios during the mission:

1. Change of the processing algorithms to cover different mission tasks (i.e. navigation, environment awareness, pattern recognition, video compression, etc.);
2. Reconfigure to sustain system failures or degradation.
3. Fast change of different non-functional critical parameters (i.e. available power or connection bandwidth);
4. Appearance of unexpected functionalities under degraded conditions or failures of some of system elements due to the challenging environment.

The use case is mainly focusing on integrating a multi-core platform capable of in-flight reconfiguration in actual video processing equipment that will be used for both earth

observation platforms and robotic payloads for planetary exploration. The target is to replace legacy designs in actual flight missions using more efficient, adaptable, designs capable of overcoming classic ASIC designs and allowing to comply with the strict constraints of cost and mass imposed by the New Space paradigm.

12.3 Product User Requirements and Differentiation

As described, the main FitOptiVis target is the development of a generic reconfigurable Video Processing platform with in flight reconfiguration capabilities. This generic platform will then be customized into different flavors to cover different market needs:

1. Generic Video Processing Platform: Non-commercial development used as base for the rest of developments and to validate the different algorithms to be implemented
2. Low Cost Adaptive Video Processor: Targeted to the next generation of EO constellations being defined under the New Space paradigm, this unit will be designed to be as generic as possible so that it can be manufactured at an external EMS in large quantities. In this unit reconfiguration is used in two ways:
    a. *Reconfiguration for Customization*: A generic video processing platform is manufactured in large quantities at a fraction of the cost of a standard unit. These platforms are then adapted to the different mission needs through reconfiguration before delivery.
    b. *Reconfiguration for Hardening*: These units will use low cost commercial components with a reduced endurance to the radiation effects. In order to survive the harsh space conditions these low cost devices will include failure detection and self healing reconfiguration protocols that will rearrange the internal processing elements of the FPGA allocating them on those areas not damaged by the radiation.
3. High End Adaptive Video Processor: These units will be tailor made for classic planetary exploration missions. The target of these processors is to integrate in one single element, with one or various sensors, all the image related functions. For example, for a lunar landing mission, the following missions could be covered by the Video Processor through reconfiguration at each stage:
    a. *Startracker Camera*: By implementing star detection, centroiding and pattern correlation algorithms the main mission camera can be used as star tracker for the orbital and interplanetary travel.
    b. *Image Assisted Landing*: Implementing edge detection, image comparison and pattern recognition, the main camera can be used to guide the lander module using crater maps as reference to select and reach the landing spot.
    c. *Exploration Camera*: Once landed the main mission camera would behave as a traditional science camera, acquiring images of the lander surroundings. Here noise reduction, interferometry and image compression algorithms would be configured into the video processor.

As shown, the FitOptiVis developments to cover safe and qualified dynamic reconfiguration for Video Processing algorithms will be key in the development of the proposed products, starting by the generic platform and its subsequent derivation to cover the different targeted markets.

12.4 Total Market Envisioned

As shown, there are two clear markets for the proposed Reconfigurable Video Processor:

1. Planetary Missions Market: TASE proposes, based in the FitOptiVis developments a one stop solution for planetary missions. The proposed standard video processing platform supporting adaptive video processing that allows to cover with a single unit several roles during the mission will mean dividing by three the cost of the overall video processing subsystem for a traditional planetary exploration mission. This market, typically led by agencies such as ESA or NASA, presents a small number of units with a high development and recurrent cost per unit. As baseline, TASE foresees to sell 2 units of the High End Adaptive Video Processor per year starting on 2024. Each of these units would have a target proce of 400K€ per unit thus totalizing a target market of 800K€ per year
2. Earth Observation Constellation Market: Pulled by the telecommunication market, the Earth Observation market is evolving to deliver high resolution images in near real time at a fraction of their current cost. To satisfy these needs, the new megaconstellations have appeared in the space sector. Systems formed by more than a hundred satellites flying in low orbit, interconnected with each other and with terrestrial communication networks. Its objective is to provide specialized imaging services with very low latency and short revisit times. These megaconstellations are able, thanks to their orbit and architecture, to reduce the latency of the connections compared to the geostationary orbit by establishing links several hundred kilometers long instead of the 36,000 kilometers of the geostationary orbit. Likewise, their low height allows them to greatly improve the image performances.

Currently, the market for megaconstellations has been considered by both classic operators and new space market players who have approached this sector under the New Space paradigm, with which they aim to reduce all costs of development, production, orbiting and operation of these systems.

Both of them intend to develop these new constellations with new features and maintaining a great operational and functional flexibility that allows them to adapt to the evolution of market needs. In this environment, the flexibility, compactness a low cost of the proposed Adaptive Video Processor and associated solutions is a fundamental part.

The proposed development is oriented to cover the needs of the coming Earth Observation megaconstellations that are currently being defined by becoming the Video Processing core component of different low cost and high volume instruments. The proposed solutions will have enough processing capacity to be able to perform the required processing as well as managing the resources of the instrument and to adapt it to the different configurations that the target constellation may adopt, since different satellites that occupy different positions in the constellation may have different needs and functions.

The market for megaconstellations is in full swing and several initiatives promoted by different operators are already underway. As indicated in the attached table, the

potential market for these megaconstellations exceeds 1400 units in the coming years. Most operators of these megaconstellations have contacted Thales Alenia Space to request initial budgets for the corresponding payloads. The objective for TASE is to sell 200 units per year, starting 2026 at 50K€ per unit thus totalizing a volume of 10M€ per year.

12.5 Commercial State-of-the-Art and Competitors Analysis

Due to the nature of the Space market, the exploitation of FitOptiVis through the space use case, driven by TASE, will be strictly global as there are no national markets in the space business.

TASE aims at validating a reconfigurable video processor, based on FitOptiVis principles, to be applied to robotic planetary exploration missions as well as to Earth Observation missions. The successful adoption of MPSoC architectures for Video Processing in the space domain will open a completely new field for MPSoC architectures that are entering at a very slow path in the space domain due its stringent reliability, dependability and predictability constraints. FitOptiVis will be the enabler to put the basis to boost the usage of reconfigurable MPSoC platforms in the Space Market.

Regarding the market structure, the space sector is a small market where most of the times the competitors at low tier level (Unit manufacturers) are, at the same time, partners at higher levels. It is very frequent that an ESA mission is assigned to a prime contractor (e.g.: Thales Alenia Space) that then subcontracts a subsystem to another partner (Airbus) that, in turn, comes back to the first to purchase some units of that subsystem.

TASE as main actor of the exploitation of the Space Market will profit of its fluent contacts both in and outside Europe. In Europe TASE provides regularly video processing solutions to the main satellite integrators such as Airbus Defence and Space, OHB and, of course, Thales Alenia Space itself. In this line, TASE is delivering the Video Processing Units for the next generation of the Meteosat satellites, thus having a clear path to propose developments for future video processor generations.

Outside Europe, TASE is a well-known provider of American prime satellite contractors such as Space Systems Loral and has also delivered video units to countries like Korea (GK2 satellite), Turkey (Turksat) or Egypt.

12.6 Standardization Activities

Although, strictly speaking, the Space Domain is not regulated in terms of systems safety or dependability, the ESA standards (ECSS family of standards) can be considered as a de-facto regulation of what the vast majority of space end users and customers will accept in their systems. Presently CPS are not included in these standards and, for the initial prototypes and demonstrators, no barriers are expected. However, space has been traditionally a very slow adopter of new technologies and solutions. In order to speed up the technology adoption, TASE intends to initiate specific dissemination and exploitation actions involving ESA. As one of the key actors in the Space market, TASE will present the FitOptiVis results to the key actors in ESA and ECSS with the target of including the proposed tools and methodologies as part of the

next edition of the space engineering and space quality standards. More precisely, contributions are foreseen to the ECSS-E-ST-40 series (Space SW), ECSS-E-ST-70 series (Ground testing) and ECSS-Q-ST-60 series (ASIC and FPGA development)

13 IPR Planning IPR Management Strategy

For the operation of a successful FitOptiVis project, it is important to have a sustainable IPR strategy in place so that all partners of the consortium work collaboratively in a coherent manner towards the achievement of common objectives.

The FitOptiVis IPR strategy has been focused and very clear in order to best protect the innovations and knowledge developed within the time-frame of the project from attacks by competitors. This will also help in maximising the returns on the human, capital and intellectual investments. The management of knowledge is handled in the signed grant agreement, rule for participation and Consortium Agreement (CA) between the all partners.

The management of knowledge and intellectual property and other aspects of innovation in FitOptiVis project are allocated to specific activities within work packages. They are twofold: on the one hand IPR applications for new systems and solutions will be prepared by participants. On the other hand, information will be disseminated within the project and to external bodies through publications, presentations and regulatory and standards bodies, but only after the necessary steps for ensuring the protection of IPRs have been considered in the first year. This ensures that IP will be secured in the interest of project partners.

The dissemination of information and the influence, e.g., on standards bodies, are the prerequisites for the economic success of IPRs. In addition to the CA, this specific exploitation and innovation plan has been set up when the first results of the project will be submitted to the Commission and be reviewed yearly.

During the life of FitOptiVis, the implementation of these IPR strategy and principles will comprise the following main tasks:

- Keeping list of background included/excluded: collect, update and maintain the list of background included/excluded by each partner as specified in the CA.
- Management of the FitOptiVis foreground portfolio: collect information on the foreground generated in the project. The FitOptiVis foreground portfolio will be the key tool for dissemination and exploitation of the project results.
- Knowledge projection: propose a general policy regarding co-ownership of knowledge and moderate solutions in case of co-ownership between different beneficiaries and provide advice about knowledge project when required (patents, copyrights, etc.).
- CA maintenance and evolution: maintain the Consortium Agreement and prepare corresponding decisions to be taken by the Steering Committee related to modifications of the pre-existing know-how, termination of participation and entrance of partners according to procedures defined in CA.

The implementation of these IPR principles and exploitation preparation will be under the responsibility of the Coordinator, who will report on a regular basis and whenever requested to the General Assembly.

Besides the internal rules for IP management reported in the CA, FitOptiVis partners have carefully considered how to provide adequate protection for the exploitable results that promise to be of any potential for commercial and industrial exploitation.

Since to define the most suitable form of IP protection the character of the results has to be first identified, the first step the partners made was to define a preliminary IP protection model of Exploitable Results as presented in the Table 2.

Subject Matter	Patent	Utility Model	Industrial Design	Copyright	Trade Mark	Confidential Information
Invention (e.g. device, process, method)	X	X				X
Software	(X)	X		X		X
Scientific Article				X		
Design of a product			X	X	X	
Name of a technology / product					X	
Know How	X	X				X
Website			X	X	X	

Table 2: IP protection Strategies

This first-year deliverable is the initial version of the plan for IPR strategy and the generated knowledge and products of the FitOptiVis project. This plan will be completed along the life of the project and will not become final until the end of it. The IPR strategy plan is designed not only as a vehicle to communicate the activities of the project and for the general awareness of opportunities but also as a “knowledge sharing” initiative, as a platform to favour the establishment of new links with industry and academic stakeholders.

14 Open Source Exploitation and Educational Activities

14.1 Open Source Exploitation

Open source is an enabler to promote or establish standards, as well as a powerful marketing channel and a ticket to collaboration. Furthermore, it has demonstrated to be a way for the creation of new market opportunities. Indeed, a general trend is visible: for a specific, often highly specialized, application area there is no market for tooling, but the tool application itself creates a market. There is no market for compilers, but there is a market for the usage of tools (programmers); there is hardly any market for system modelling tools, but there is a market for model and expert on modelling.

Some partners have already started or planned the distribution of their achievements in an open source manner. Table 3 below summarizes the list of these products and the primary information for each of them.

Name	Involved Partner(s)	Scope/ Reference Community	Availability	Links to Material
SDF3	TUE	Dataflow analysis and synthesis	Available	Tool Website: http://www.es.ele.tue.nl/sdf3
PARETO	TUE	Pareto Calculator	Available	Tool Website: http://www.es.ele.tue.nl/pareto
TTA	TUT	TTA-based Co-Design Environment	Available	Tool Website: http://tce.cs.tut.fi/
ABILITY	ABI	Ability a fully GNU / Linux distribution for embedded systems	Available	Tool Website: http://ability.abinsula.com/
MDC	UNISS UNICA	Coarse-Grained Reconfigurable Platform Generator	2nd year of the project	Tool Website: http://sites.unica.it/rpct/ Tutorial on Available Features: https://www.youtube.com/watch?v=_cyYFJCDR3U&list=PLql1YxTzHalZztJPu7wn0uzAYbr81QTpH
SAGE-VS	UNISS	Tools (Req-V and Hydra) for formal verification tasks	Available	Req-V on Gitlab: https://gitlab.sagelab.it/sage/ReqV Req-V web-page: http://www.sagelab.it/reqv/ Hydra on Gitlab: https://gitlab.sagelab.it/sage/hydra Hydra web-page: http://www.sagelab.it/hydra/

Table 3: Planned Open Source Results

In other case there is the commitment to make results available before the end of the project, as in the following cases:

- UNIVAQ intends to release a prototypal version of its tools for HW/SW co-design and multi-core platforms on FPGA integrated with HW profiling system.

Nevertheless, open access alone is not enough; therefore, FitOptiVis partners are going to develope an Open Source Strategy to foster accessibility of technologies and, at the same time, to drive the creation of an environment favoring innovation processes both inside and outside the consortium, during and after the project. The complete strategy will be completed during the second year of the project.

14.2 Educational Activities

FitOptiVis findings and results are intended to be used by many different academic partners in the courses, bachelor/master Thesis, and PhD Thesis they offer. In our exploitation plan these are effective instruments to bring FitOptiVis knowledge beyond the project and the consortiums itself, since at least part of the involved students will probability be employed somewhere else.

Type of Activity [seminar, academic course, invited talk, workshop, tutorial, PhD Thesis, Bachelor Thesis, Master Thesis]	Involved Partner(s)	Topic/Title
Tutorial at the CPS&IoT'2019 Summer School on Cyber-Physical Systems and Internet-of-Things, Budva, Montenegro, June 10-14, 2019	UNISS UNICA	"Dataflow-Based Toolchain for Adaptive Hardware Accelerators"

Table 4: Academic Usage of FitOptiVis Results