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Smartification of Home Appliances for Safety Assessment and Risk Alert

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Abstract: The developments in production processes are a need in times that require more efficiency, improved costumer engagement and customized smart solutions. In order to meet such criteria, the fabrication processes must be adjusted to meet those new requirements and engage in new production paradigms. Technology is now able to supply parts and processes for manufacture of new products as those emerging from the growing smartification of everything. In that sense, the present research work targets the process of smartification of furniture pieces and its associated process of fabrication. 3D printing, sensors and smart devices are all components of the smartification process that, as proposed in the present document, will support the development of new smart furniture pieces. The smartification process consists in enabling such furniture to monitor and react accordingly to human behaviour by identifying accidents or potential risks to persons at indoor facilities. The result hereby presented is a strategy to create smart home appliances that will become smarter than traditional furniture and thus become able to detect risks and react accordingly. The behaviour consists in alerting the person or someone responsible for their safety and assistance, either at home or in a care facility, to enable prompt response and promote their wellbeing.

Keywords: Manufacturing, sensors, Integration, Intelligent, positioning systems, risk, safety analysis

1. INTRODUCTION

The environment around us is becoming smart and connected. Personal devices, machines and equipment and even vehicles are enriched with sensors while empowered with processing capabilities. A benchmark on that reality is the wide spread use of computers and smartphones that are able to capture data, analyse it, use processing capabilities to react accordingly and seamlessly interface with the user. The fact is that almost everywhere at every time a myriad of sensors and communication devices are collecting data that, once analysed, provide services and solutions to assist users or make life easier. It all started with the Internet of Things (IoT) concept. Internet of Things proposes an environment littered with communicating objects, with a pervasive presence around us of a variety of things, or objects, such as Radio-Frequency Identification (RFID), tags, sensors, actuators, mobile phones, etc. These networked objects will be visible in both working and domestic fields, with possible scenarios in domotics, assisted living, e-health and enhanced learning as possible examples of this new paradigm with a leading role in a near future. (Atzori, Iera and Morabito, 2010). IoT is considered as an ecosystem that contains smart objects equipped with sensors, networking and processing technologies integrating and working together to provide an environment in which smart services are taken to the end users (Asghari, Rahmani and Javadi, 2019). IoT is materialized in sensing and communication devices that connect with other devices generating data and information that become useful while analysed and deployed to services and applications. Smartification aims to improve existing objects or situations so that it becomes more functional, efficient and interactive. It includes traditional objects or situations. Examples of that are smartphones where a phone becomes much more capable than providing phone connectivity and becomes a smart-phone or even a city that, with the empowerment of devices and networks. become a Smart City. To make that append, architectures make use of such panoply of available smart objects to make common objects and situations to become part of that smart ecosystem. In overall, there is the Internet of things as enabler to the usage of devices that become part of the smartified architectures. In that sense smart objects provide awareness of the overall environmental conditions around us. If associated with intelligent systems, as those resulting from AI algorithms, using big data collections to feed machine-learning analysis, it becomes supportive and proactive for a person's benefit. Those smartified furniture pieces are provided with sensors to enable awareness of the environment. This can be the result of a fabrication process where manufacturers include sensing and communication devices but can also result from the transformation of existing pieces by modification (e.g. hatching and engraving) new electronic devices. This kind of solution is import for the

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healthcare domain especially to be deployed at home for people with limited abilities that can become at risk while alone at home. It can also be part of a more complex smart environment by the inclusion on a larger architecture but also addressing pre-established requirements to assist a person (e.g. dementia patient) providing security for the patient and ease the stress for carers. In overall, with the lack of commercial solutions and business in this area, the concepts of Do-it-Yourself and Do-it-together are presented, in the scope of the INEDIT European Research Project, envisaging own development as a solution for this lack of available option. This area is still in early stages as can be confirmed by the lack of references either in industry or scientific publications.

2. PERSONALIZED MANUFACTURE

The present times are seen as an industrial revolution, so called Industry 4.0, which holds the promise of increased flexibility in manufacturing, along with mass customization, better quality, and improved productivity. It thus enables companies to cope with the challenges of producing increasingly individualized products with a short lead-time to market and higher quality. Intelligent manufacturing plays an important role in Industry 4.0. Typical resources are converted into intelligent objects so that they are able to sense, act, and behave within a smart environment (Zhong *et al.*, 2017). That is significantly different from the existing production paradigms, essentially by the smartization that is an advancement from the objective of coping with the market, and costumers, needs. Now there are devices that can empower such a revolution and that can contribute to a new generation of advanced products that are also highly customized and personalized to the client needs.

The technological innovation of Industry 4.0 opens new possibilities for bespoke and unique designs all rooted in the same technology and supported by the same services. Taken together, Cyber-Physical Systems, Cloud Computing and Internet of Things offer a neutral platform for the creation of hybrid digital physical objects (Petrelli, 2017).

With such developments of the Industrial Revolution 4.0, many new types of systems are being designed, introduced, or attempted, even in almost every traditional industry. The use of continuously developing production equipment and Information and Communication Technology (ICT) has a single objective, providing a customized service to all customers (Yuan *et al.*, 2018). But sometimes the technology reaches the people and empowers the citizen to participate in a world once closed to production companies. The symbolic example of such paradigm is 3D printing at accessible costs.

There has been little explicit consideration of do-it-yourself (DIY) in previous manufacturing literature. This may be because traditional DIY is an outlet for physical goods that are made-to-forecast, such as boats kits for self-assembly and personal use. DIY invention and production are able to create physical goods, which are both original and economical, through open, distributed, minimal processes. Within the existing paradigm, by contrast, physical goods are created, which are either original or economical, through processes that are less open, less distributed, and less minimal than the processes of new-DIY (Fox, 2013).

The concept of do-it-together (DIT) is not likely to appear in literature. It aims at a co-creation of objects for the benefit of different customers with similar needs. Maybe we can clarify, from literature, that the most similar concept to (DIT) and (DIT), aiming to address one's needs, would be the mass customization, but that one is not a collaboration but rather a personalized manufacture that addresses each customer needs. Mass Customization is the ability to provide individually designed products and services to every customer through high process agility, flexibility and integration, thus Mass Customization systems may reach customers as in the mass market economy but treat them individually as in the pre-industrial economies (Davis, 1997). In this case there are two sides, the manufacturer and the client which is not the same for (DIY) or even (DYT).

3. IoT, CPS AND SMARTIFICATION

Smartification in the present case aims at developing smart environments by a process of including smart objects. Those smart objects can be fabricated with that aim and thus including electronic devices but can also result from adapting existing objects by engraving sensing and communication devices but also by attaching those devices without emboding them. The path to smartification makes use of tome other existing concepts such as the Internet of Things (IoT) and Cyber Physical Systems (CPS).

Internet of Things predicts the future that, the advance digital world and the physical world will get linked by means of proper information and wireless communication system technologies (Misra et al., 2019). The combination of the Internet and emerging technologies such as near-field communications, real-time localization, and embedded sensors lets us transform everyday objects into smart objects that can understand and react to their environment. Such objects are building blocks for the Internet of Things and enable novel computing applications (Kortuem et al., 2010).

Cyber-physical systems (CPS) are physical and engineered systems whose operations are monitored, coordinated, controlled and integrated by a computing and communication core. Just as the internet transformed how humans interact with one another, cyber-physical systems will transform how we interact with the physical world around us (Rajkumar et al., 2010).

Smartification in the present case of home appliances, has the application of this concepts to the furniture equipment along with other CPS or IoT equipment that may exist in the house, to promote personal safety and, if necessary, to trigger the necessary help measures. The instantiation hereby presented has the objective of enable furniture pieces to become "smart" and match the requirements to participate on an IoT ecosystem where everything becomes connected and useful for citizens. In what regards to furniture, the integration of sensors and actuators will attribute a behavioural pattern that will allow such pieces to sense the environment and to activate actuators that will interact with other devices, M2M, and with people either at home or remotely located. Then it becomes possible that home environments will get connected and smart in many ways. The usage of smartification would

range from environmental conditions (e.g. temperature, movement and vibration) identifying critical situations (e.g. flood, fire, earthquake) but can also ask for health assistance once detected a fall or excessive passive time of a person. Such appliance of smart objects to integrate in furniture would promote a customized degree of interaction according to each individual's needs. Such smartification strategy is well fitted in the Industry 4.0 of a new Industrial Revolution.

4. SMARTIFIED FURNITURE

The main objective of smartification is to turn common objects or systems into smart versions that will, ultimately, provide a better function towards addressing human needs. In that sense, the smartification of furniture empowers the objects once used for resting or doing day life activities (e.g. having meals, studying working) into active objects capable of performing a sort of assessment of present context awareness and actively provide the most adequate responses according to the resulting evaluation. In Fig. 1 it is depicted a common chair converted in smart-chair with the addition of the sensors and the Control Unit (C-U). The Control Unit will be able to retrieve communications from the sensors, either wireless or wired and to ensure communication with other devices like smartphones or wi-fi networks. The left and right sensor together provide the means to monitor the heartrate and even proceed to ECG measurements. The sensor sit will detect the presence of a person and will also be able to monitor restlessness or extensive periods of steadiness. The back sensor will also be able to detect movement patterns and posture while sited. Additionally, the system can be able to measure the weight of the person along the time and detect rapid movements as in the case the person falls over, he sits or even if the person falls over the chair.

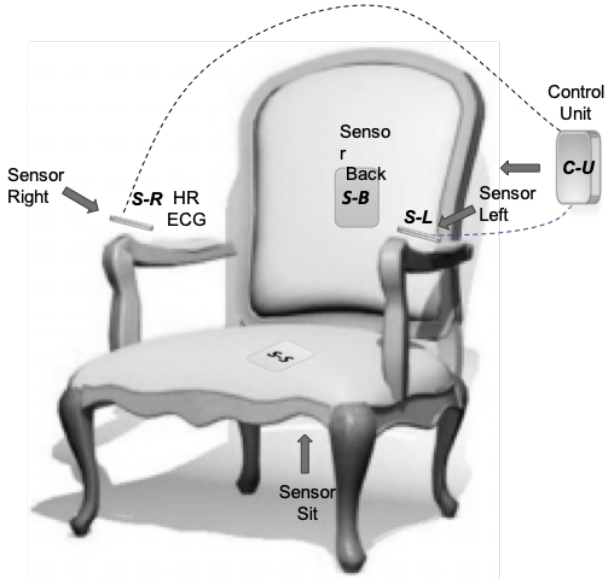

Fig. 1 – Smartified Chair

In Fig. 2 is possible to observe a table smart-table where the smart term results from the inclusion of selected sensors and a Control Unit. The presented example consists in a table manufactured as a smart-table with embedded sensors but can also result from the transformation from a conventional table that is enriched with a pack of sensors that provide sensing and communication capabilities. Such table will be able to detect the presence of individuals and the kind of pressure those individuals are exerting over the table. It is achieved with measurements over weight sensors 1 to 4 below the feet of the table. This will make possible to determine if the person is alone and if there is a worrying excessive steadiness over the table. It will also be able to detect id a person had a fall over the table. The vibration sensor, placed below the table, will make possible the assessment of activity of the person and, using A.I. to train a Neural Network to learn what are the usual patterns of vibration, related with activities and detect abnormalities. Those events will trigger the proper action being some sort of communication with the user or a request for help.

The Control Units (C.U.) are, in both cases, the units able to collect all data, analyze it and determine the proper reaction to take. That assessment is based on the requirements early established for the system to operate but are also resulting from the current situation awareness thus identifying if there is some action to take and what kind of action that would be executed. The C.U. will have communication, wired or wireless with the sensors (e.g. Bluetooth, LTE or Wi-Fi) but can also have Wi-Fi to interact with the neighboring smart objects in a Machine to Machine interaction (M2M) but can also interact with webservices or users (e.g. 3G, 4G or next 5G). In what regards to Data analysis, from single operating rules to complex A.I. analysis, that assessment plays a vital role on the relevance of the smartified object. In that sense, analysis and computation can be made locally, for the simple processes, or remotely to contain battery usage and extend battery life. That is the case of the usage of cloud services to analyze big chunks of collected data but also to execute neural network analysis or to run machine learning algorithms that would, otherwise, drain the battery.

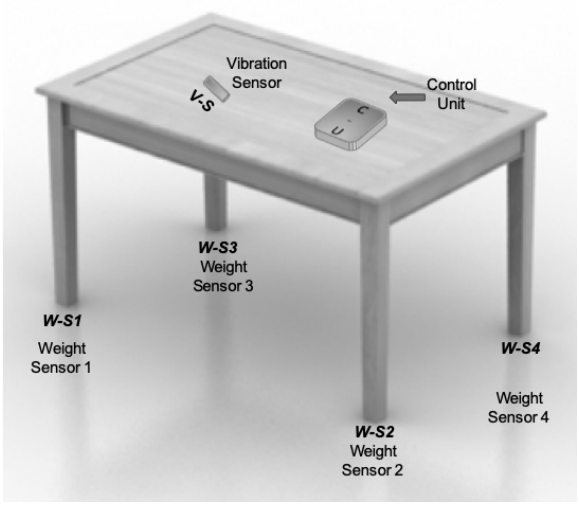

Fig. 2 - Smartified Table

The proposed solutions aim, essentially, persons that are alone at home or people living together but with high degrees of health limitations, either in terms of cognitive impairments or physical limitations. This is the case of people suffering

from Dementia that have these kinds of risks that can happen while going out and forgetting where they are and what they where supposed to go. The risks with the outside world were covered in several works in the scope of the CARELINK project that the present work also contributes (Luis-Ferreira *et al.*, 2018), (Luis-Ferreira *et al.*, 2019), (Rodrigues *et al.*, 2018). Home should be the place where a person feels secure and protected. Nevertheless, while at home, alone, the home can present a serious threat especially if the person puts herself at home and becomes unable to ask for help. The aim of the present work is also to re-center the home as a safe place to match reality to this idea of home as a safe place.

The work developed so far presents a series of technological deployments that were prepared to assist patients with Dementia and, in particular, the Alzheimer's Disease. But at home it becomes much more complicated to determine what is natural (e.g. laying rapidly in bad, or sitting quickly), from what is an accident (e.g. falling on the ground, falling over a table). That is where home appliances, together, can make a significant contribution in identifying the risks and provide alert once a critical situation is detected.

Those generic solutions can also be adapted to other situations like babies, that in a moment of distraction, may become exposed to serious consequences which can be mitigated if the home appliances are, as proposed, smartified. Those objects, making part of the home space, can also be part of a more complex environment where hazards like flooding and fire can be perceived along with the detection of the existence of intruders at home.

5. CONCLUSIONS

The present research is fostering a new area of smartification in the Furniture domain completing the pack of traditional home appliances. If other appliances are already smart (e.g. A/C, blinds, Smart TV) here are no references, in literature, to Furniture smartification as this area seems unexplored so far. The closest approaches to this topic come from the usage of IoT devices that are once used home space could try to cope with the lack of smartification of the furniture. In that case the topic is smart homes that consists in introducing sensors and automation to the home, not exactly aiming, by that means, the process of converting furniture or promoting the fabrication of smart furniture and other home appliances. That is also the starting point to the research presented here. This new domain consists in improving the manufacturing process of home appliances to take in consideration the inclusion of sensing and communication components. It becomes even more relevant by highlighting the possibility of improvement of existing furniture to accommodate IoT sensors and transforming a common piece of furniture into a smart-furniture kind of object. This strategy is aligned with Cyber Physical Systems, Internet of Things, the smartification of environments and, in overall, with the Industry 4.0 paradigm. It is also relevant the fact that manufacturers can adopt such strategy to provide smartified furniture and thus improve their products and reach new markets but also to consider the empowerment of individuals in taking the initiative of smartifying their own pieces. This process can be supported by 3D printers, engraving laser printings or even through the collaboration with a Fab Lab facility. The research carried so far will be executed in the scope of the EU H2020 project INEDIT: open INnovation Ecosystems for Do It Together process.

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