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An infrastructure for individualised and intelligent decision-making and negotiation in cyber-physical systems

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Abstract

Cyber-physical systems are often developed with an emphasis on the network of computational elements and the linkage between the computational and physical elements. The physical elements are different kinds of Internet of Things devices that carry out desirable and valid tasks from instructions. However, due to the limitations of current individual-based secure products and delivery of services, the requisites of these products and services have started to increase and, hence, the requirements for intelligent automated, networked and mobile devices arise. The current state of communication between the elements in Internet of Things is data exchange and needs step up to next level to improve the interaction with the surrounding devices to augmenting human capabilities. This paper presents an infrastructure for individualised intelligent decision-making and negotiation in cyber-physical systems with smart Internet of Things devices. The decision-making and negotiation is based on individual preferences to provide the best individual-based solutions. The solution is applied to health care, which will permeate throughout the paper.

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Keywords: Cyber-Physical Systems; Internet of Things devices, Intelligent reasoning; Decision-making; Negotiation

1. Introduction

With the growth of population, the requisites of individual-based secure service deliveries with requirements for intelligent automated, networked and mobile devices will increase. Current reports present increasing need for

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improved infrastructure of intelligent devices that supports people in their daily life. For health care, for example, there are a lot of people that cannot get treatment and medicine and, hence, medical systems must support these services and products by becoming more intelligent in the ways they interact with human users and each other. To provide more individualised intelligent health care, multi-disciplinary research is needed to make possible comprehensive lifelong multi-source health records for individuals. Hence, the requirement is to have things that act, intelligently, and accordingly to pre-defined characteristics and requisites. Thus, the need of intelligent behaviour has arisen and with it, research in an advanced Cyber-physical systems using Internet of Things with devices supporting augmented reality. Necessary and essential individual-based data and information can be retrieved and decision-making can support the exchange of data and information between the different devices in the system.

Augmented reality with smart products and services has started to influence our lives, providing an abundance of advanced and useful research in Internet of Things (IoT)[1,2,3]. This research has been successfully carried out to provide digital support. IoT is a network of things with tagged identifiers that carry out tasks when objects approach the devices. The tasks are based on immediate and present needs and should give applicable support according to data communicated between the end user and the IoT. Currently, the communication between the elements is a simple data exchange, which needs to step up to next level to improve the interaction with surrounding IoT devices to augment human capabilities.

Internet of things can be reckoned as a distributed cyber-physical system with loosely coupled interacting components, or devices. Cyber-physical systems (CPS) are often developed as a network of computational elements with linkage between the computational and physical elements[4]. The physical elements often use different kinds of IoT devices to handle significant data and information, which are needed to carry out desirable and valid tasks[4-10]. CPS can handle an exchange of the required data, information, knowledge and experiences between the devices. However, different devices require various input-output technologies.

Augmented reality[1] using Cyber-physical systems with the smart IoT devices that provide products and services can assist people in especially dangerous environments. This can enable monitoring and delivering healthcare, operation in dangerous and inaccessible environments, coordinating traffic and efficient use of energy in buildings. In particular, the devices can effectuate automatically opening doors for disabled people in the surrounding environment, and providing necessary and adaptive interfaces for visual impaired and/or hearing-impaired people. Moreover, these devices can provide individualised information for different situations, such as, obtaining individual-based information by receiving patient records with earlier diseases, current and earlier treatments and medications, thus providing fast and instant help for unexpected illness and so on. Hence, providing information is not just to provide any information, it must provide user-requested and user-adapted information.

To get the best possible solution, governed by user needs, the control of the CPS, with near field sensors and other IoT devices, must include individualised, intelligent interactions between humans and CPS. The interaction requires decision-making and negotiation with smart IoT devices to improve the interaction with surrounding devices to augment human capabilities. Strategies for decision-making and negotiations[11], using event-driven algorithms[12,13], are necessary to support individuals by making intelligent conclusions from the data sets. These conclusions must be based on the needs of commonalties and requirements of particular outcomes using individualised, secure and intelligent IoT devices. This paper presents an infrastructure for individualised, intelligent decision-making and negotiation in CPS creating a need-adjusted environment with individual-based performing IoT devices. Research in CPS is, commonly, carried out for the utility network and not for a holistic view of the problem and improved situation for the individuals, as in this paper. The focus moves from ‘what can you do in the environment’ to ‘what the environment can do for you’. As an example of the research, CPS is applied to health care handling required, individual and necessary patient data obtained from monitoring and measuring the current general status of the patient’s health, including earlier health issues, and drawing conclusions about medicine usage and side-affects, which is then presented to medical doctors and other users.

2. Infrastructure centered around a personal IoT device, MINi-Me

There are several different operating environments that can occur in the CPS, which is viewed as infrastructure for the CPS system. The emphasis of the infrastructure lies in designing modules in the environments. An