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Smart world: a better world

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Abstract With the advancement of technologies, our world is becoming a smart world. In this paper, we share our vision of a smart world, demonstrate different application scenarios and introduce the emerging techniques. We envision that in a smart world, we will become more connected, safe, productive and efficient. To enable a smart world, many advanced techniques such as advanced network, ubiquitous sensing and collaborative computation have been developed. More specifically, they include heterogeneous advanced wireless networks, intelligent transportation, accurate indoor localisation, wireless sensor network, unobtrusive human behaviour sensing and mobile cloud computing. Compared with the previous work, the proposed techniques are faster, more accurate and non-invasive. We firmly believe that by exploiting those techniques, the smart world will be a better world.

Keywords smart world, emerging techniques, sensing

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1 Introduction

Thanks to the rapid penetration of smart devices, the dense deployment of supporting infrastructures and fast advancement of techniques in communication, sensing and computation, numerous novel intelligent applications will emerge in the near future. In this paper, we will present how we can be more connected with the help of advanced heterogeneous network; how we can commute in a fast and safe manner with intelligent transportation system; how we can stay safer in our working places thanks to the advance of accurate indoor localisation techniques; how construction workers can perform structure health diagnosis by exploiting wireless sensor network; how we can obtain more information of an object simply by taking a photo; how we can control wheelchair and play games with our sitting posture; and how we obtain our vital signs with non-invasive platforms.

To enable the above-mentioned applications, many novel techniques have been developed, including fast and seamless handoff in advanced heterogeneous network [1]; collision avoidance and traffic light schedule in intelligent transportation system [2]; nanotron-based indoor localisation techniques; structure health monitoring using wireless sensor network [3]; mobile augmented reality using mobile cloud computing [4]; sitting posture recognition based on pressure sensors [5] and respiration rate detection with Wi-Fi signal sensing [6].

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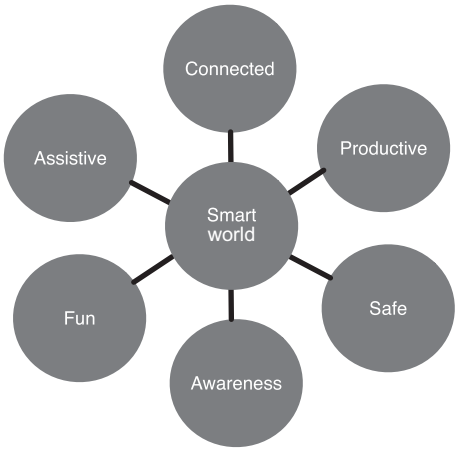

Figure 1 The vision of a smart world.

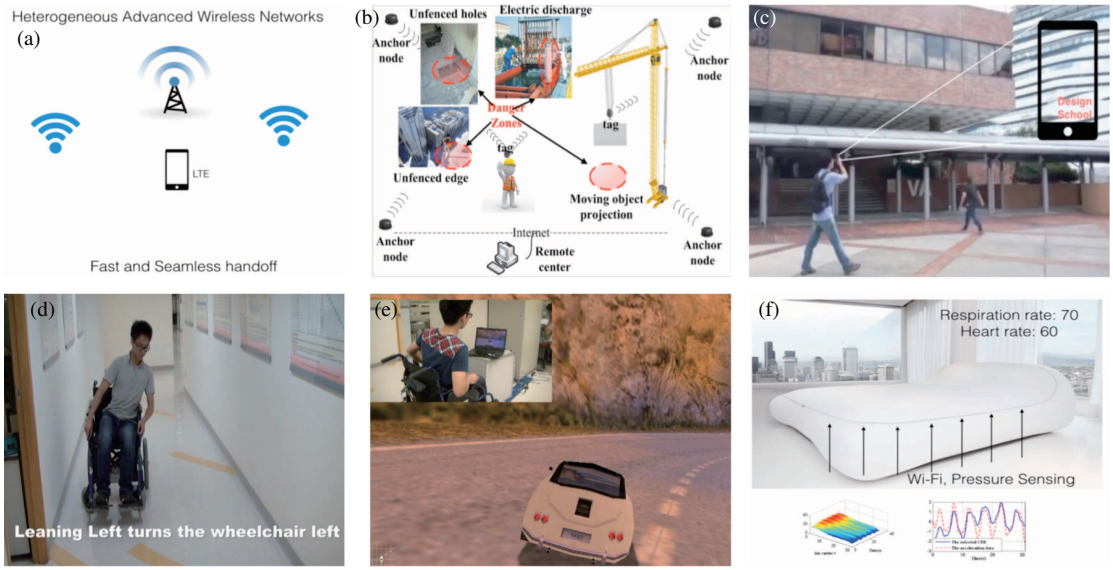

Figure 2 (Color online) Representative emerging applications. (a) seamless communication; (b) safe helmet; (c) video-based navigation; (d) posture-based wheelchair control; (e) posture-based game interaction; (f) non-invasive monitoring.

We believe that in the not so distant future, those techniques will be weaved into every fabrics of our life. As shown in Figure 1, we firmly believe that by exploiting those techniques, we will live in a smart world which allows us to be more connected, safer, more productive, more assisted, happier and more aware of our health status.

The main contributions of the proposed techniques are as follows. First, the data transmission is faster due to the advanced heterogenous network. Second, the computation of mobile nodes is speeded up due to the collaboration with cloud server. Third, the ubiquitous sensing is more accurate and non-invasive with the advancement of the sensors and recognition algorithms.

2 Emerging applications

In this section, we describe some representative emerging applications ranging from seamless communication to non-invasive sensing (See Figure 2).

Seamless communication. We will experience seamless communication experience in the near future. In particular, the mobile phone will be able to seamlessly switch over different networks (e.g., LTE, Wi-Fi) without interfering with user experience [1].

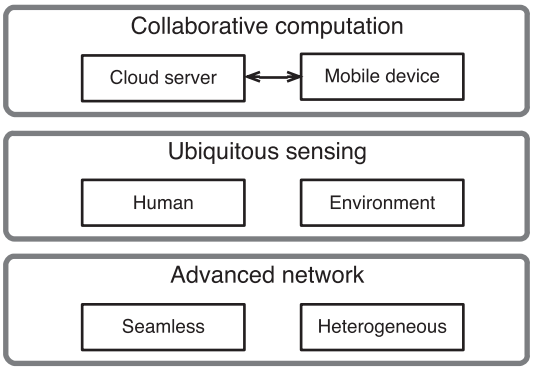

Figure 3 System framework of underlying techniques for intelligent applications.

Smart transportation. Smart car is around the corner. With the help of various sensors, smart car is able to detect accident and avoid collision. Meanwhile, the traffic light scheduling will be adjusted optimally based on the traffic flow [2].

Safe helmet. In working place, we become more protected with the help of smart technologies. For example, construction workers will be alerted once he/she is close to a dangerous zone. The trick is that those workers will wear a smart helmet which can provide accurate indoor location [7].

Mobile augmented reality. By leveraging the computation power of cloud server, an ordinary mobile device can execute computation-intensive application such as augmented reality [4]. For instance, it allows users to conduct video-based navigation on an off-the-shelf mobile phone.

Body as the interface. An emerging trend in human computer interaction is to use our body as the interaction interface. In particular, we can control sitting posture to play games or control the wheelchair [5]. Using body as the interaction interface can support the patient for rehabilitation and underpin many novel gaming applications.

Non-invasive monitoring. Most of the current monitoring platform requires the user to wear specialised devices. With the advancement of sensing technologies, we can achieve monitoring in a non-invasive and contactless manner. Some research studies have demonstrated the feasibility of extracting people's vital signs such as heart rate and respiration rate using fibre sensors in the seat cushion or even Wi-Fi signals around the environment [6].

3 Enabling techniques

To enable a smart world, we propose a system framework which incorporates new enabling techniques in different system layers. As shown in Figure 3, the system framework consists of three components: advanced network, ubiquitous sensing and collaborative computation. Specifically, advanced network is able to offer seamless communication services over heterogeneous networks. Ubiquitous sensing can infer the fine-grained context of both human and environment in a non-invasive manner. Collaborative computation enables the computation partition and execution across mobile devices and cloud servers to make the best of both worlds.

3.1 Advanced network

Compared with the current networking service, advanced network can offer seamless communication. In order to achieve this, the key point is that we should have fast and seamless handoff over heterogeneous network.

Advanced heterogeneous network. One of the representative advanced network project is conducted in [1]. In this project, a fast and seamless handoff protocol for advanced heterogeneous network is designed and implemented. This protocol supports the seamless communication service across cellular network, Wi-Fi network and mesh network.

3.2 Ubiquitous sensing

Ubiquitous sensing focuses on inferring fine-grained context of both environment and human. Specifically, environmental sensing includes structure health monitoring and human sensing includes indoor localization, sitting posture recognition and respiration detection.

WSN-based structure health monitoring. Recently, wireless sensor network (WSN) has been deployed on a building to detect possible structural damage which is called structure health monitoring. The basic idea is that structural damage can be detected through the vibrational features which are extracted from sensor data. An optimal coverage solution has been proposed in [3] to meet the application needs while reducing the energy consumption.

Accurate indoor localisation. Location is one of the most important user contexts. Thus, accurate indoor localisation is highly desirable. A smart helmet is designed in [7], which leverages Nanotron chips to perform accurate indoor localisation so as to improve the safety of construction workers. The proposed solution is anchor-based and can locate large numbers of objects simultaneously using clustering strategy.

Sitting posture recognition. Sitting posture is critical to someone's health, because poor sitting postures can cause upper limb and neck disorder. An accurate, low-cost and non-intrusive sitting posture recognition system is presented in [5]. The basic idea is that different sitting postures are associated with different pressure distribution and patterns on the top of a chair. In particular, the system incorporates very thin pressure sensors to offer non-intrusive experience, an effective sensor placement solution to reduce cost, a set of user-invariant features and an ensemble learning classifier to improve generalization ability.

Wi-Fi sensing. Another emerging sensing technology is to infer human's activity or even vital signs from existing Wi-Fi signal. In [6], authors presented Wi-Sleep system which is able to extract fine-grained sleep information like a person's respiration, sleeping postures and rollovers from Wi-Fi signals. More specifically, Wi-Sleep uses off-the-shelf WiFi devices to collect the fine-grained wireless channel state information (CSI) around a person. Based on the CSI, the patterns associated with respiration and abrupt changes due to the body movement can be extracted. The biggest advantage of Wi-Sleep is that it is completely contactless, while the existing sleep monitoring systems require people to attach special devices on the body.

3.3 Collaborative computation

In order to provide the best user experience of mobile device, one trending solution is to augment mobile device with the cloud resources. In particular, the mobile device can partition the computation tasks and offload some tasks to the cloud so as to boost the speed.

Mobile cloud computing. Paper [4] proposes a mobile cloud computing framework which augments the execution of mobile applications on portable devices using cloud resources. More specifically, they study how to achieve the maximum process speed/throughput by optimising the computation partitioning of a data stream application between the mobile and cloud.

4 Literature review

Current solutions for sitting posture recognition, however, are impractical due to intrusiveness, high cost or low accuracy. A wearable sensor-based method attaches an inertial sensor on a user's back to collect motion data and identify the sitting posture [8]. This approach is intrusive and brings discomfort to users, since users are required to wear or attach those sensors. Vision-based methods use cameras to capture user sitting postures [9]. Such method requires line-of-sight condition and may raise privacy concerns. To achieve a non-intrusive and privacy-preserving solution, researchers have deployed pressure sensors on the chair to infer sitting posture [10, 11]. But the main limitation of these solutions are the high cost (around 3000 USD), since they rely on high-fidelity pressure sensor array with more than two hundred sensors.

5 Conclusion

We are entering a world with intelligence. In this paper, we share our vision of a smart world, highlight some representative applications and propose a system framework which covers the underlying techniques. We envision that people in a smart world will be far more connected, safer, more productive and healthier. To realise this vision, novel techniques have been designed and implemented in different system layers: advanced network, ubiquitous sensing and collaborative computation. In a nutshell, we believe that a smart world allows us to live a better life.

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Conflict of interest The authors declare that they have no conflict of interest.

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