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IoT sensors management system using Agile-Kanban and its application for weather measurement and electric wheelchair management

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Abstract

Purpose – Recently, Internet of Things (IoT) devices and sensors are rapidly increasing in the word. They are connecting to the internet and are generating vast packets in the network. Thus, the networks could be congested, and the performance will degrade. For this reason, it is important to decrease the number of transmitted packets. Agile is a technique to develop the software and manage the work efficiently. Kanban is a method to support Agile development. The purpose of this paper is to propose an IoT sensors management system considering Agile–Kanban and show its application for weather measurement and electric wheelchair management.

Design/methodology/approach – The authors present the design and implementation of two systems and show the measurement device, data communication failure and experimental results.

Findings – The proposed Agile–Kanban system can manage a large amount of IoT sensors and can decrease the IoT sensor's consumption power thus increasing the IoT sensor lifetime.

Originality/value – By experimental results, the authors have shown that the proposed systems have good performance and can control the IoT devices efficiently.

Keywords IoT technologies, Agile–Kanban, Electric wheelchair management system, Weather measurement system, Web-based systems

Paper type Research paper

1. Introduction

Recently, many communication systems have been developed to support humans. Especially, Internet of Things (IoT) technologies, IoT devices and sensors can provide many services for humans. The IoT sensors can be embedded in electronic devices. For instance, if a refrigerator has some IoT sensors inside, it can tell us the ingredients for cooking through the internet anytime and anywhere. The temperature of the air conditioner in the room can be controlled. Also, television, cooking heater, microwave, bath-unit, toilet-unit, light and so on are going to provide new services.

Currently, the vehicles can be connected to the internet and Toyota uses the word: "Connected Car System." This system can collect the data using mobile network and sensors in the car. These are different kinds of data such as the data taken by the car when is moving, car speed, braking or acceleration, weather condition and traffic jam information.

These data are gathered to the datacenter through the network by using internet technologies. The data can be analyzed and used for solving some traffic problems. There

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are also other applications using IoT such as the use of IoT technologies for agriculture, factories, offices, schools, hospitals and so on.

Because the IoT devices and sensors generate a huge amount of packets, the network load is increased and the sensor lifetime decreases. The lifetime of O_2 sensors is in the range of 4–8 years and for ozone sensors is in the range of 1–2 years. To increase the lifetime of these kinds of sensors some new systems and approached are needed.

We consider the use of Agile and Kanban (the meaning of Kanban in Japanese is sign board) for management of IoT sensors. Agile is software developing method that denotes the quality of being agile, readiness for motion, nimbleness, activity, dexterity in motion. The software development methods can offer the answer to the business community asking for lighter weight along with faster and nimbler software development processes (Abrahamsson *et al.*, 2017; Kiely *et al.*, 2017). Kanban is one of methods that can support Agile process (Petersen, 2016). In this work, we present two systems: the weather measurement system and electric wheelchair management system using Agile–Kanban.

The structure of this paper is as follows. In Section 2, we introduce the IoT and Kanban. In Section 3, we present our implemented IoT sensors management system with Agile–Kanban. In Sections 4 and 5, we explain application for a weather measurement system and application for electric wheelchair management system. In Section 6, we show the conclusions and future work.

2. IoT and Kanban

2.1 IoT

Our life style is drastically changing by IoT technologies. The IoT can our quality of life by connecting various things to the internet such as household electronics appliances, vehicles, robots, communication devices and some application software.

In Figure 1, we show the image of IoT environment. The IoT system has many sensors, which can be used for operating factories, farms, offices, houses and so on. However, given the fact that most of IoT sensors are resource limited and operate on batteries, the consumption power and life time of sensors are important issues for wireless IoT sensor networks design (Nair *et al.*, 2015; Sheng *et al.*, 2015).

There are some approaches for decreasing the number of packets in these networks. The Opportunistic Networks (OppNets) is one of them. It can provide an alternative way to support the diffusion of information in special locations in a city, particularly in crowded spaces where current wireless technologies can exhibit congestion issues (Miralda *et al.*, 2018).

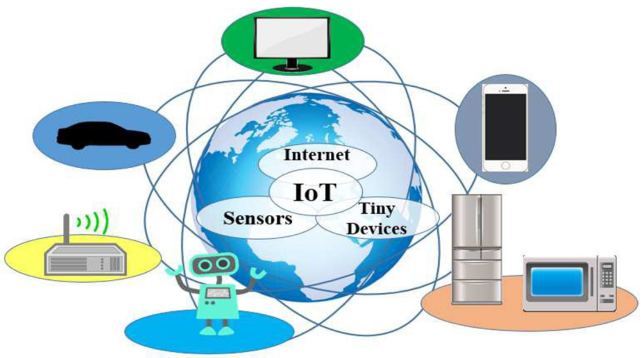


Figure 1.
Image of IoT environment

2.2 Kanban

Kanban is a system produced by Toyota. The system can efficiently produces vehicles. The main goal of Kanban was to produce cars for the same or lower price than the competitors. This Kanban system is called Toyota Production System (TPS). The TPS is also known as Just in Time manufacturing and the basic principle is to produce only what is needed, when it is needed and in the amount needed. Currently, there are many research work using Kanban for developing software (Kirovska and Koceski, 2015; Maneva *et al.*, 2016; Yacoub *et al.*, 2016). At the beginning, the Kanban was used in manufacturing processes; however, its applications in other areas is continuously growing owing to its proven successfulness.

We have shown a schematic illustration of Kanban system in Figure 2. The system has two Kanbans and the Kanban system has three sections: upstream, downstream and store. The upstream section role is for manufacturing parts by making some blocks of products. Downstream section is used for assembling parts and completing the products. Store section is used for keeping some parts needed for working operation. If the amount of stocking parts increases, the manufacturing efficiency decreases. To solve this problem, Kanban system uses Production-Kanban and Withdraw-Kanban. The upstream section produces some parts and stock them in the store section, while the downstream section uses the parts in the store to assemble the products. The Production-Kanban can only move between upstream and store, while the Withdraw-Kanban is moving between store and downstream as shown in Figure 2.

We describe the moving of Kanbans in Figure 3. If there is a shortage of parts in downstream section, the Withdraw-Kanban moves from downstream section to store section. Then, the

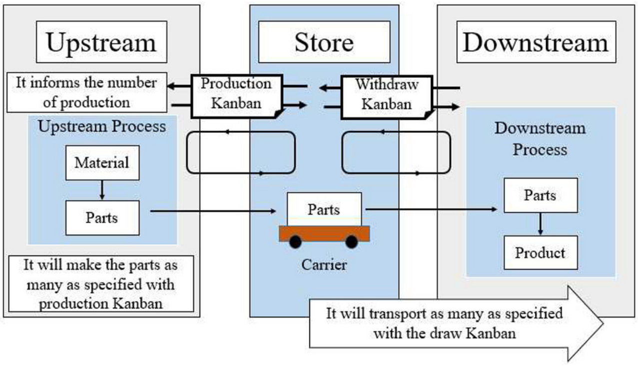


Figure 2.
Structure of Kanban system

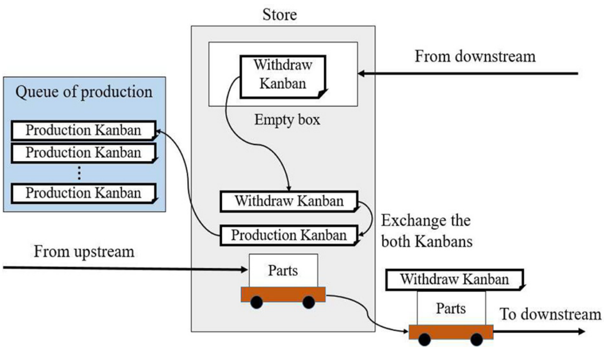


Figure 3.
Moving of production-Kanban and withdraw-Kanban

Withdraw-Kanban informs the number of shortage parts to Production-Kanban. After that, the Production-Kanban instructs the upstream section to manufacture the number of shortage parts informed by Withdraw-Kanban. The Production-Kanban will put the number of shortage parts in the production queue and then the production of parts will start. Thus, the Kanban system can control the supply and demand of parts, which leads to an efficient manufacturing.

Recently, Kanban system combined with Agile is used for software development. Some papers use Kanban and Agile for collaboration work (Hofmann *et al.*, 2018; Padmanabhan, 2018). In another paper, the authors use Agile approach with Kanban for managing the security risk on e-commerce (Dorca *et al.*, 2016).

3. Implemented IoT sensors management system with Agile–Kanban

In Section 3, we present IoT sensor management system considering Agile–Kanban (Figure 4). This system uses Kanboard. The Kanboard requires the Web server, database and PHP. The Kanboard offers four kinds of Kanbans to users which are Backlog, Ready, Work in progress and Done. Each Kanban description is shown in Table 1.

3.1 Overview of Kanboard

The Kanboard is a free and open source software (Kanboard, 2020), and its user interface is shown in Figure 5. The Kanboard focus on simplicity minimalism and the number of features is limited. By Kanboard can be known the current status of a project because it is visual. It is very easy to understand, and there is no need to explain and no training is required.

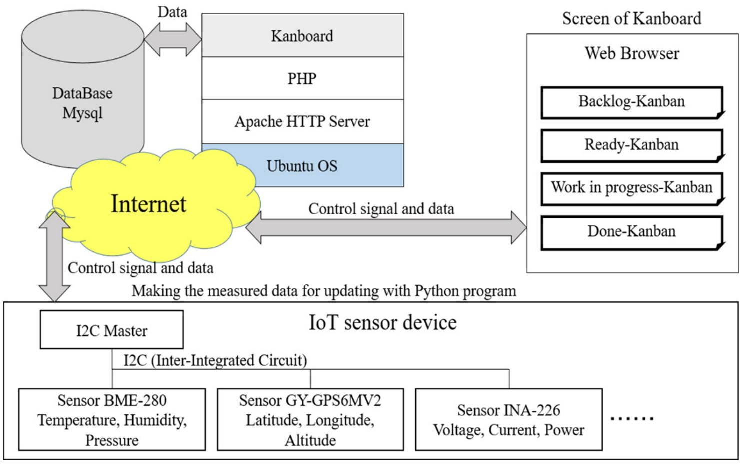


Figure 4.
Agile–Kanban system

Table 1.
Description of kanban names

Name of kanban	Description
Backlog	The sensor needs maintenance
Ready	The sensor is ready for using
Work in progress	The sensor is working
Done	The sensor finish the work

The Kanboard has a number of features as follows.

- action visualization;
- limit work in progress to focus on the goal;
- drag and drop tasks to manage the project;
- self-hosted; and
- simple installation.

In Figure 5, we present a user interface of Kanboard, which shows four Kanbans: Backlog, Ready, Work in progress and Done.

3.2 IoT sensors management system

IoT sensors management system can manage various kinds of sensors. One Kanban corresponds to one sensor. The Kanban can change some states with drag and drop. For example, when there is a Kanban in the state of Backlog, it means that the sensor needs to do maintenance. When Kanban is in the state of Ready, it means that the sensor is ready to be used. Work in progress means the sensor is working. In this case, the measurement data by sensor will be uploaded to the database on the internet. When Kanban is in the state of Done, it means the end of work.

Figure 6 shows the user interface of IoT management system. When the Kanban is in the "Work in progress" state, the measurement data of temperature and humidity are shown in

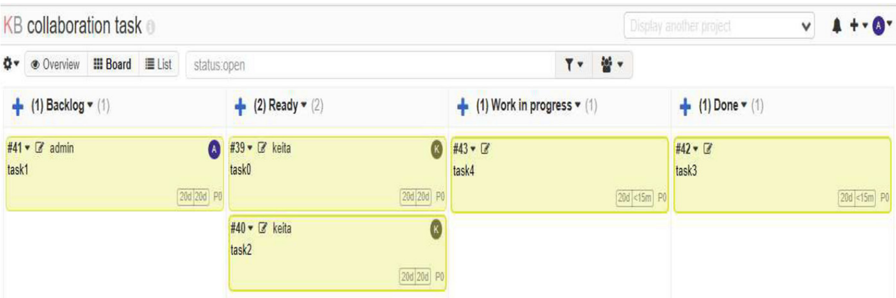


Figure 5.
User interface of Kanboard

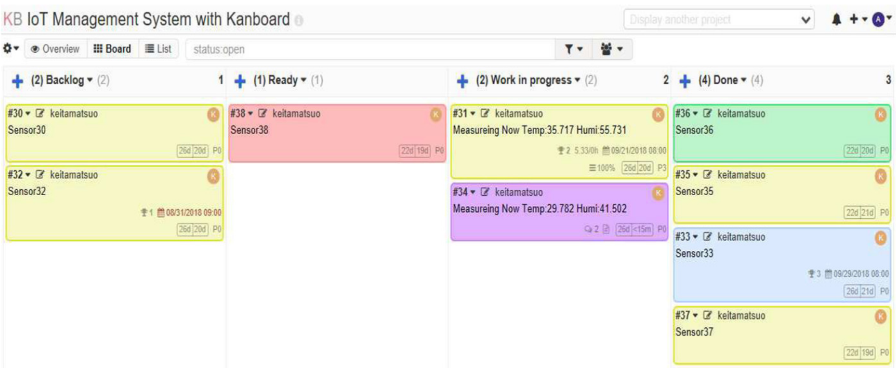


Figure 6.
User interface of IoT management system

Figure 7. In Figure 8 is shown the image of moving Kanban on the IoT sensor management system using Kanboard. By using IoT sensors management system can be managed a large amount of IoT sensors. When the IoT sensors are not used, the management system can cut down the consumption power for saving IoT sensor's battery. Only when the users are using the IoT sensor, the sensors are able to communicate through the network. This means that the system can reduce the wasted packets. The system is able to analyze the IoT sensors status such as sensor's working time, life time, frequency of use and sensor's activity. The system can be installed in factory machines, vehicles, robots, offices or school facilities, home electrical appliances and so on.

4. Weather measurement system

To use our proposed IoT sensors management system, we implemented some weather measurement devices as shown in Figure 9. The device can measure some data, e.g. temperature, humidity and pressure. Figure 10 shows the image of collecting data with IoT sensors from real environment. The measured data can be sent to the database through the internet from anywhere.

4.1 Weather measurement device

Our proposed IoT sensors management system can handle various sensors. The features of this sensors device (weather measurement device) are as following.

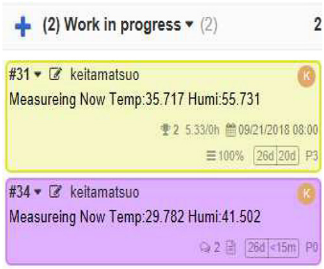


Figure 7.
Image of measured data on the Kanban

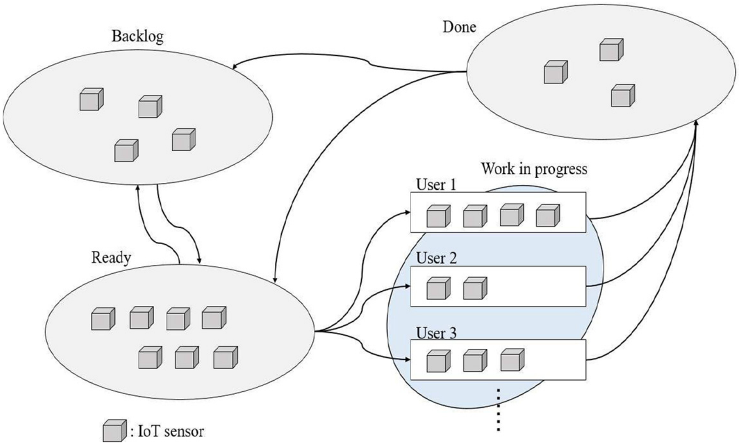


Figure 8.
Different states of Kanban moving

- It is assumed to be used outside and allows to turn the measuring instrument on and off without using a monitor, mouse or keyboard.
- The operating light (LED) can show the states of device (Table 2).
- The device can use any internet connection, e.g. WiFi, cell phone, WiMax and MVNO.
- The IoT device can get self-position with GPS.
- The device can use 112 sensors.

In addition, it is possible to display some measured data of the place on the map as shown in Figure 11.

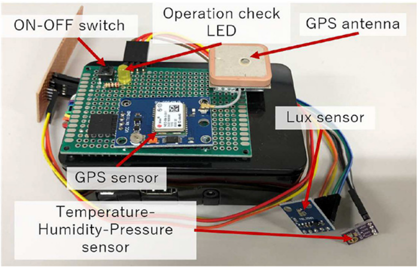


Figure 9. Weather measurement device

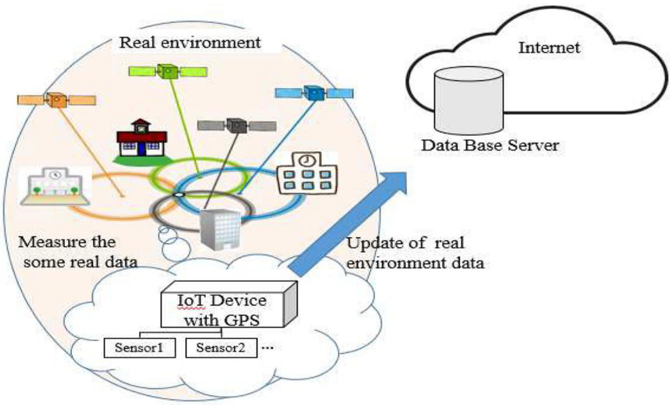


Figure 10. Image of correcting data with IoT sensors from real environment

Table 2. States of operating light

States of device	States of operation light (LED)
Backlog	Turn off the operating light
Ready	The operating light is blinking every 3 s
Work in progress	The operating light is blinking every 1 s
Done	The operating light is blinking every 0.5 s

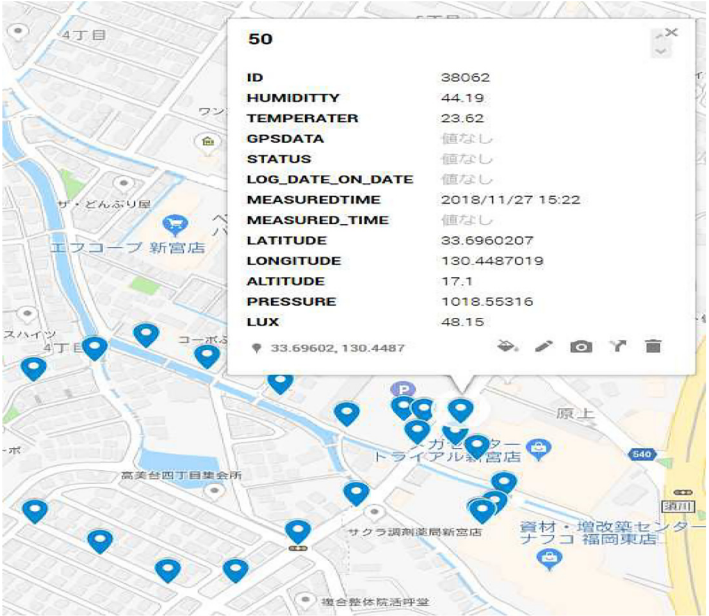


Figure 11.
Image of measured points for weather data

4.2 Data communication failure

Figure 12 shows a flow chart of data communication failure. If the sensors device cannot access the database, the device will make some data files by themselves. After that, when the system is recovered for uploading the measurement data to the database, the sensors device will start to send back up files to the database.

5. Electric wheelchair management system

With the rapid development of science and technology, traditional hand-propelled wheelchairs have gradually evolved into electric wheelchairs that can be operated by individuals with mobility impairments (Tseng *et al.*, 2018). Handicapped persons require

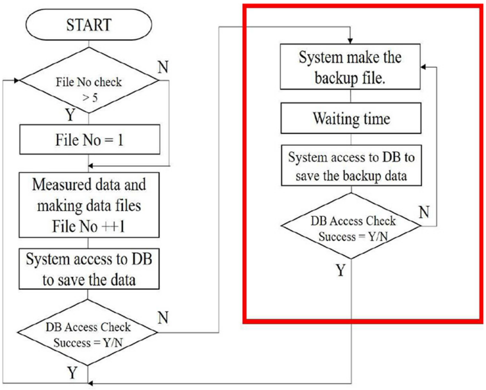


Figure 12.
Flowchart of data communication failure

higher-quality electric wheelchairs to move freely in the home, at work or in hospitals. These electric wheelchairs will require through maintenance checks for its overall condition and more focused checks on the batteries and current, voltage and temperature of the motor.

Hospitals, nursing or elderly care facilities need many electric wheelchairs and consequently will require a great deal of time and manpower to manage and maintain them. Therefore, we propose an electric wheelchair management system that can manage many electric wheelchairs using Agile–Kanban.

Figure 6 shows the user interface of the proposed management system, and Figure 13 shows its schematic illustration. The Kanbans can move in different states, such as Backlog, Ready, Work in progress and Done. One Kanban corresponds to one wheelchair.

The Kanban can change some states with drag and drop. For example, when there is a Kanban in the state of Backlog, it means that the wheelchair requires maintenance. When Kanban is in the state of Ready, it means that the wheelchair is ready to be used. Work in progress means the wheelchair is working. In this case, the measurement data of wheelchair by sensors will be uploaded to the database. When Kanban is in the state of Done, it means the end of work.

The proposed system has used Scikit-learn to detect some states of wheelchair. Scikit-learn is an open source software for machine learning. Scikit-learn has a number of algorithms that support vector machine, random forest, k-means clustering and neural networks. We use neural networks for predicting the states of wheelchair. Figure 14 shows a diagram of machine learning, and Figure 15 shows a diagram of using neuron that has two medium layers. We can predict a battery's states using this model. When if the battery is in

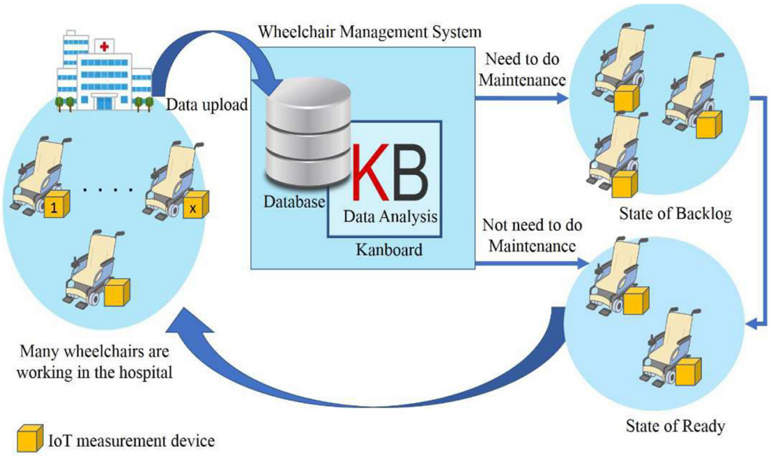


Figure 13.
Schematic illustration of proposed wheelchair management system

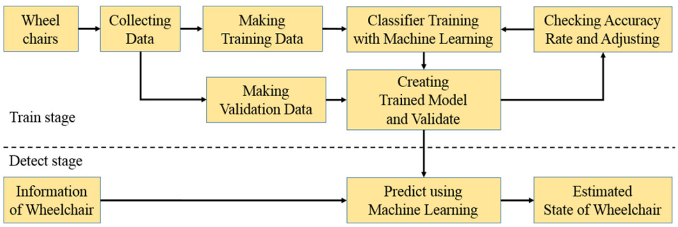


Figure 14.
Diagram of machine learning

bad condition, the corresponding wheelchair's Kanban moves to the Backlog section automatically. After that the wheelchair's battery will get recharged or replaced.

We implemented the IoT device to measure the states of the wheelchair as shown in Figure 16. The device can track the wheelchair's states, including the battery's voltage, the motor's current and so on.

When the Kanban is in the "Work in progress" state, the measured data of the voltage, current and temperature of the battery are shown in Figure 17.

6. Experimental results

To check the states of wheelchair battery, we used Scikit-learn (Figures 18, 19, 20). Figure 18(a) shows the validation result for 1,000 learning times, and Figure 18(b) shows the loss function. Figure 19(a) shows the validation result for 3,000 learning times, and Figure 19(b) shows the loss function. Figure 20(a) shows the validation result for 10,000 learning times, and Figure 20(b) shows the loss function.

Table 3 shows the results of detecting the wheelchair's battery states. The highest accuracy is achieved for 3,000 learning times. We see that the result of 10,000 learning times have less accuracy than 3,000 learning times because of an over learning time. We must find the optimal parameters for keeping the wheelchairs in good condition. After that, we can decide wheelchair's battery state using this method. We think that this process can be applied to any trackable state of the wheelchair.

7. Conclusions and future work

In this paper, we introduced Agile–Kanban. We presented in details the Kanban system and Kanboard. The system can manage a large amount of IoT sensors. Our proposed system can

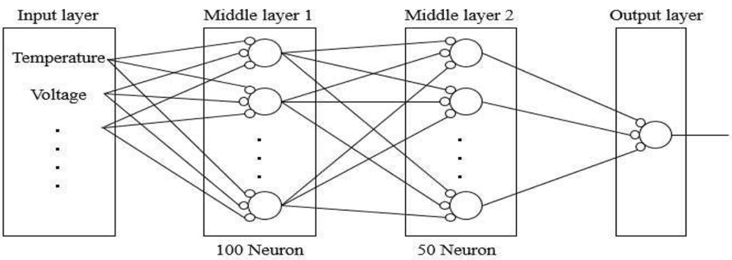


Figure 15.
Diagram of using neuron

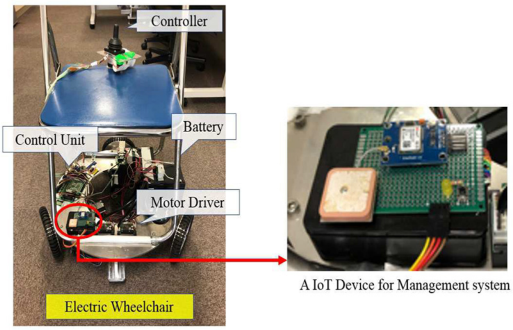


Figure 16.
IoT device for wheelchair management system

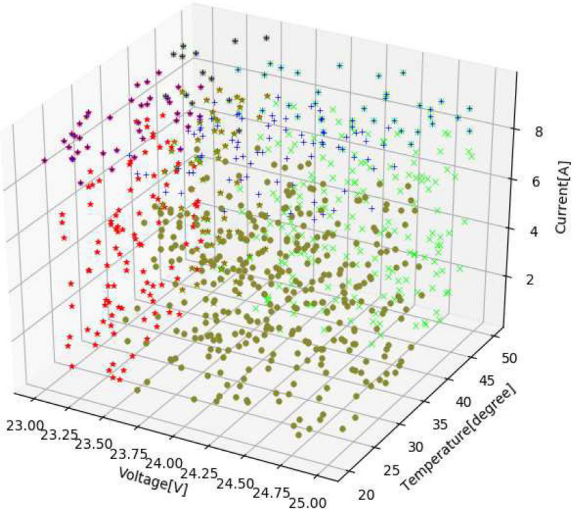
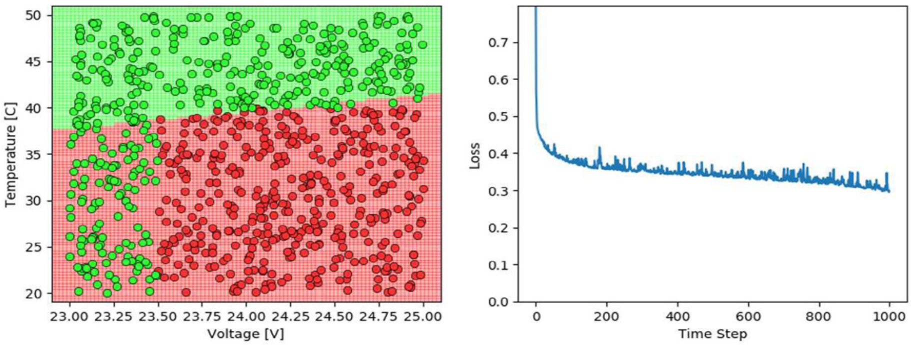
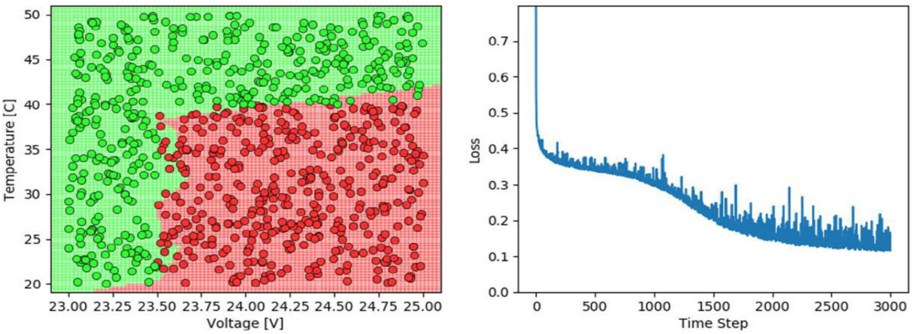


Figure 17.
Measured data on the wheelchair



(a) (b)

Figure 18.
Validation result with 1,000 times of learning



(a) (b)

Figure 19.
Validation result with 3,000 times of learning

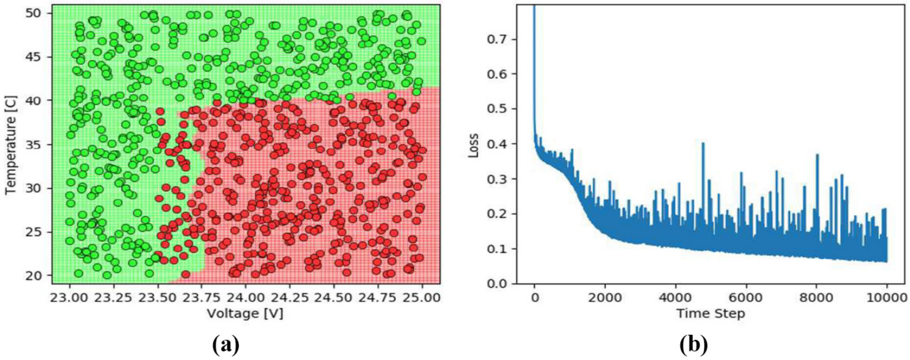


Figure 20.
Validation result with 10,000 times of learning

Table 3.
Results of detecting wheelchair's battery states

Number of learning times	Accuracy rate
1,000	84.05%
3,000	96.52%
10,000	93.17%

decrease the IoT sensor's consumption power thus increasing the IoT sensor lifetime. By making an efficient management, the communication traffic is decreased. In addition, we implemented two systems: a weather measurement system and an electric wheelchair management system.

In the future work, we would like to improve the proposed system and carry out extensive experiments.

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