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Virtual Sensors and Its Applications in Smart City

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Abstract

The importance given to smart cities is increasing day by day. With the development of smart cities, it is of great importance to find solutions to the problems of smart cities or to make smart cities better. Many advantages will be provided by reducing the use of physical sensors in city life. The most important advantage will be the cost issue by reducing the number of physical sensors. Virtual sensors are used instead of physical sensors. It is used to predict future values in systems that provide a continuous output based on the measurements of real sensors periodically. By using virtual sensors instead of physical sensors used in many application areas of smart cities, it is ensured that the areas in the city are monitored or controlled. The virtual sensors replace the actual sensor when the physical sensor defects. Using virtual sensors in smart cities, remote devices can be managed using wireless sensor networks and devices can be monitored. The virtual sensor allows better control of the systems in the smart city, thus the performance of the system is also increasing. With the use of virtual sensors, human intervention in different systems is reduced and the control capability of the systems increases.

Keywords: *Applications, Condition monitoring, Smart city, Virtual sensor*

1. Introduction

The virtual sensors are used instead of physical sensors. In cases where the physical sensor is too slow as a result of the operation, when the physical sensor is too slow as a result of the operation, in cases where the physical sensor is too slow, it is used instead of the actual sensor when there is no way to establish a physical sensor [1]. Data on the estimated result to use the virtual sensor is collected. Then a mathematical model is created with data modeling software. In principle, the virtual sensor is a kind of software that makes the operations of a physical sensor otherwise, given the current information. In addition, the virtual sensor learns to interpret the relationships between different variables and observes the readings from different tools. The basic idea behind the virtual sensor; If a simulation is used, if the correct inputs are received and the product's real-time behavior is simulated, then this simulation model can be measured by taking measurements at different locations [2]. The virtual sensor can be placed anywhere on the simulation model. In most cases, it may not be possible to place the physical sensor where we want it. Other reasons for choosing a virtual sensor are cost and reliability [3]. The use of a sensor node for monitoring critical devices improves the computing and detection capabilities of devices connected via wireless communication [4]. With the widespread use of smart cities in recent years, many studies have been developed to develop devices and applications in the smart city. The virtual sensor is a new research area that has emerged in recent years. Therefore, the number of studies developed with the virtual sensor is limited. The use of the virtual sensor area in smart cities will provide many conveniences. Some of the studies in the literature including the use of virtual sensors are listed below. The virtualization of sensor networks is a paradigm for improving the flexibility of the wireless sensor network, which allows the dynamic allocation of physical resources in multi-stakeholder applications [5]. Delgado et al. [5] proposed optimization algorithm aims to maximize the number of applications sharing a general physical network. In [6] article gives a brief idea of the latest developments, basic structure, standards and applications of smart (virtual) sensor technology in different fields of work. In a database approach [1], a new sensor network was proposed to evaluate the quality and value of the vehicle. Meanwhile, machine learning and data science techniques were also used. The automatic estimation capacity of the vehicle quality was shown. Based on the vehicle model, there are now more than one hundred sensors with many functions installed in a modern vehicle, and the focus of most of these sensors is to monitor the condition and safety of the vehicle [1].

Recently, the virtual sensor has opened up new ways to measure the safety and comfort of the driver. The two publicly available data sets used in this study use similar information to monitor the quality and safety of a particular type of vehicle-based on data recorded from a vehicle and provide decision support to future vehicle purchasers [1].

Raveendranathan et al. [7] offered a multi-layer task model based on the idea of Virtual Sensors to develop design modularity and design reusability. The recommended approach was implemented in the meaning of step analysis by wearable sensors. A step analysis system was revealed according to a SPINE2-based Virtual Sensor architecture and experimentally assessed [7]. Fig. 1 exhibits the set BSN-oriented virtual sensor system architecture in [7] article. A user requests specific outputs provided defined inputs. This request is supervised by the Virtual Sensor Manager, which configures a set of virtual sensors to control the computational task. Virtual sensors use the Buffer Manager to set up communication with the usage of efficient buffers. Once configured, the system is initiated, and virtual sensors contribute to present the final outputs.

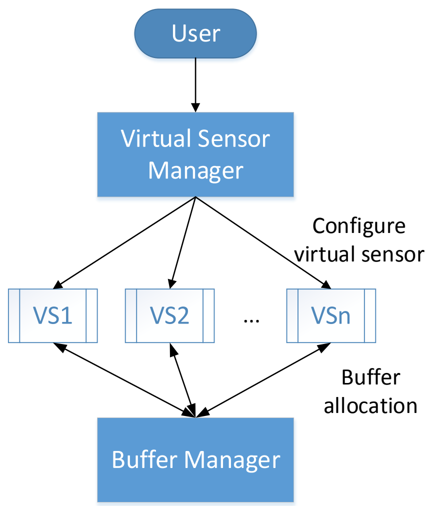

Fig. 1 Body of virtual sensor [7].

Henzen et al. [8] installed a supplementary environmental data source by equipping residents with a new variety of low-cost environmental sensor system. A critical difficulty for IoT systems is to guarantee continuous provisioning of IoT services by succeeding network failures, hardware failures, and energy reserves [9]. To defeat these concerns, in [9] study it was advised a cloud-based structure i.e SensorClone, which relies on virtual devices to develop IoT flexibility. Sensor data can be applied to promote fuel economy features [10]. Nevertheless, mounting plenty of sensors is useless in a very cost-sensitive industry [10]. Therefore, virtual sensors can displace physical sensors by decreasing cost while catching crucial motor data in [10] study.

The signal of each sensor can be measured employing the current sensor network data [11]. The measurement data are returned with the measured data in a damage detection algorithm [11]. Analytical simulations were performed for a structure subject to unknown random excitation [11]. Damage detection was based on the data from virtual sensors. Gawthrop [12] recommended the virtual actuator approach to band graph based control to use virtual sensor inputs. Reina et al. [13] introduced a novel technology that provides actual robots to observe an augmented reality environment by virtual sensors. Emirler et al. [14] assessed yaw rate using a virtual sensor which comprises kinematic relations and a velocity-scheduled Kalman filter. Kinematic evaluation is carried out using wheel speeds, dynamic tire radius, and the front wheel steering angle. In addition, a velocity-scheduled Kalman filter employing the linearized single-track model of the road vehicle is practiced in the dynamic evaluation section of the virtual sensor [14].

In this study, the use of virtual sensors in smart cities is mentioned. The use of virtual sensors in smart cities is quite wide. The use of virtual sensors has improved environmental monitoring situations. With the advantages of virtual sensors, environmental monitoring methods in smart cities produce more successful results in terms of both quality and cost. It is mentioned how to implement the use of a widespread virtual sensor in smart city. In this study, we present an overview of the use of virtual sensors and usage scenarios. Creating a virtual sensor cloud from the sensors used in smart cities provides more flexible information processing, storage, and detection services. issues discussed at the infrastructure level rather than the application level are: selecting one of the many copies of the same data detected by the different sensors, combining different perceived data about the same object, and not detecting the detected objects because of connection problems.

2. The Virtual Sensor

The virtual sensors are used in place of physical sensors and check these values by taking readings from real sensors. The virtual sensors basically consist of three stages: true sensor, process model and virtual sensor output. The virtual sensor provides control and decision based on process data [15]. The virtual sensors can replace a temporarily installed sensor, providing a continuous output based on measurements of actual sensors periodically. estimate the future of systems [16]. When the actual sensor fails, the virtual sensor can provide its durability by keeping its position. In all these cases mentioned above, a model is needed. The system model is needed to process the data from the actual sensor. A virtual sensor architecture is presented as follows.

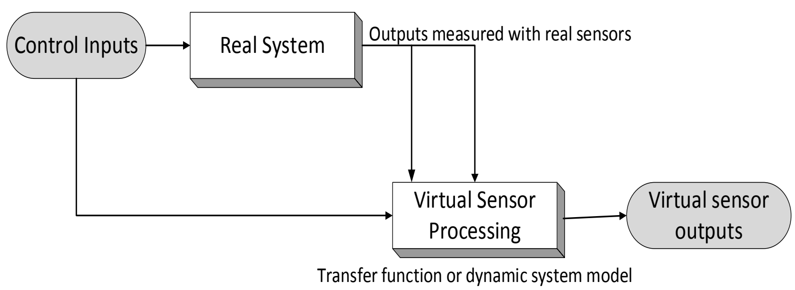

Fig. 2 The architecture of virtual sensor.

A lot of virtual sensors have been used in the application field: active noise control for virtual microphones [17], atomic energy plants [18, 19], mechanical systems [20], thermal management of a microprocessor chip [21]. physical sensors are virtualized via a general device interface via the abstraction layers in the IaaS infrastructure [22]. The virtual sensors can be used to read, control and monitor real sensors. The categories of virtual sensors in the IaaS infrastructure are as follows [22].

- Singular is the mapping between the physical sensor and its virtual state.
- Selector is the mapping of data in any of the physical sensors.
- Accumulator is the section where all of the physical sensors are collected.
- Aggregator is the mapping of the data detected from all the physical sensors to a one-to-one mapping function.
- Qualifier: the detected data is delivered when it is based on a qualifier function.
- Context Qualifier: it is based on data from one or more sensors.

The basic structure of the intelligent sensor node is presented in Fig. 3. The change in parameters is detected by the detection unit. The digital signals are generated by the signal monitoring circuit from electrical signals.

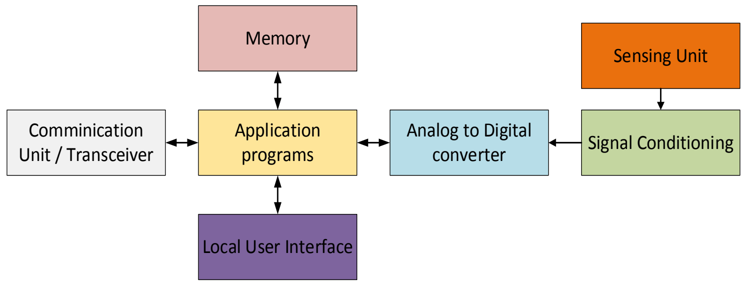

Fig. 3 The architecture of virtual sensor node.

3. Examples of The Virtual Sensor Applications in Smart City

Applications developed to monitor the environment of virtual sensors can be used for many purposes. When any sensed environment data (such as temperature) is dispatched from a special section in a city using a single sensor, a singular virtual sensor is produced. When measuring the temperature of an area in the city, multiple sensors are placed. the examination of data from each sensor is rather unnecessary and brings extra workload. Examining any of these sensors will also reach the same result. A virtual sensor is created in accordance with this target. This is a common example.

In some applications, it may be necessary to have more than one physical sensor present in the environment in order to monitor the media data. For example, in order to determine the operating temperature of the air conditioner in a smart home remotely, the humidity and temperature information of the environment is needed. Thus, using both temperature and humidity information, a value that can determine the operating value of the air conditioner can be achieved by creating an accumulator sensor. Likewise, a qualifier virtual sensor must be used when certain values in an environment are monitored and those values exceed or fall below a certain level. An example of this is the instant notification when motion data is detected on a camera in which wildlife is monitored. In areas where traffic flow in the smart city is important, it is possible to decide the duration of the traffic lights in these areas by monitoring the traffic situation. In addition, this feature can be specified separately for time zones where the day is dense and infrequent. For this purpose, a context qualifier virtual sensor can be generated.

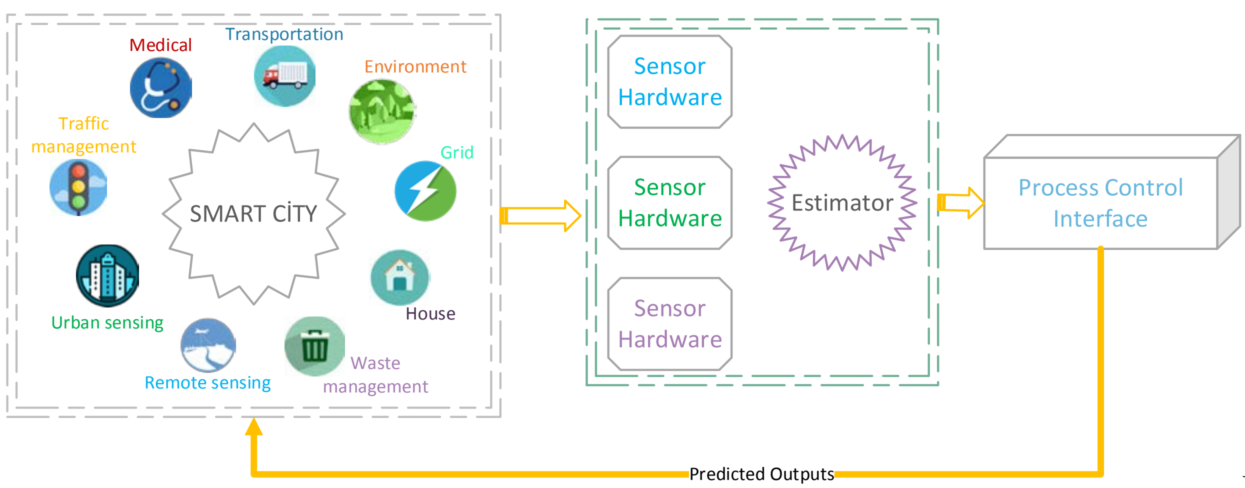

Fig. 4

Smart city solutions with virtual sensor.

3.1 Urban Sensing

In order to monitor the air pollution (quality), weather information, flood pursuit, fire monitoring, radiation status of the city, the sensor can collect data and direct the results to the evaluation system and the intelligent sensor can strengthen the ability to estimate this data. Weather forecasting in the smart city can be achieved thanks to the virtual sensor. Weather forecast data from the physical sensor can be used to make weather forecasts such as daily, weekly and monthly virtual sensors. Likewise, in the event of a fire in an unoccupied zone in the smart city, the virtual sensor can use fire fog data from the sensors to predict a fire in the area and report to the necessary places.

3.2 Wearable Ambient Sensors

Some facilities are provided by the use of a wearable environment sensor in smart cities. Some of the sensors are ready for people to wear, and both improve performance and improve in good direction. For example, with the smart chair, the sensor placed in the chair provides the most important information of the person sitting on the chair (how many hours is sitting, in which position, pulse status, movement / immobility status). These data can be converted into meaningful information and estimates in the virtual sensor.

3.3 Health Applications

It is used to obtain data for patient follow-up by means of sensors and to process them in prediction applications. Many applications such as patient monitoring system, diagnostic system, managing patient medication can be provided. For example; Alzheimer patients are constantly monitored by the camera and the patient's condition with these data is monitored through virtual sensors and notifications are provided in cases where it is required.

3.4 Remote Sensing System

For the remote control of unmanned aerial vehicles, data obtained from the physical sensors placed on the vehicle can be sent to the evaluation center and the virtual sensor can be used to guide the unmanned aircraft to the destination.

3.5 Transportation Applications

In a city with a heavily used transportation infrastructure, the traffic information of the road, route finding process, the information coming from the physical sensors are processed and the intelligent transportation system is provided by virtual sensors. Applications can be developed by offering the shortest path estimations through virtual sensors by examining the road network in the city. With the density information of the road coming from the sensors, it can also provide the convenience of eliminating the congestion in the road and making route guidance.

3.6 Smart Environment

Cities will quickly increase complexity in the way the city is not equipped to handle rapid growth. In order to provide a smart environment, an intelligent environment where water, humidity, temperature, air, and other parameters are continuously measured will be required. Thus, changes in the surrounding parameters can be controlled and environmental pollution can be prevented. One of the most important goals of smart cities is the reduction of emissions. It is possible to control the environment by placing sensors in open air locations. For this purpose, wireless sensors will need to be placed in vehicles or buildings. Therefore, the estimation of virtual sensors with information from these sensors will be provided. Pollution can be kept at the desired level.

3.7 Smart Grid

A real-time monitoring system is required to prevent power outages in the smart grid and to generate solutions when natural accidents occur. Information from wireless sensor networks can provide support for network performance and reliability for enterprises. There must be an important detection application for the smart network, which ensures that the distribution of the fall is within safe limits. In addition to monitoring and controlling the network, the virtual sensor can also monitor the power consumption of a house, thus saving power consumption

4. Conclusions

Any physical sensor can be represented by a virtual sensor system. A sensor object is created on a virtual level so that the user can interact with this sensor object, and the physical sensor is not interrupted and data loss is prevented. There are numerous sensors in almost every smart city. And this information needs to be visualized. For the city authorities to understand, it is better to turn these data into a visual application. For each data from the sensors to become meaningful, position information is needed. spatial data is very important for smart cities. Since it is not possible to monitor the position of each sensor in real time, the virtualization of these sensors will allow for easier execution of the processes. With the use of virtual sensors in place of many physical sensors used in smart cities, applications in the city can become easier. The virtual sensors replace the actual sensor when the physical sensor defects. Using virtual sensors in smart cities, remote devices can be managed using wireless sensor networks and devices can be monitored. The virtual sensor allows better control of the systems in the smart city, thus the performance of the system is also increasing. With the use of virtual sensors, human intervention in different systems is reduced and the control capability of the systems increases.

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