



## Nesnelerin interneti cihazları için kural tabanlı takip sistemi

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### ÖZET

Hayatı kolaylaştırmak için her geçen gün daha fazla cihaz geliştirilmektedir. Bu cihazların çoğu, mevcut sistemlere entegre edilerek veya yeni sistemler olarak kontrol edilebilir ve uzaktan izlenebilirler. Nesnelerin İnterneti dönemi ile, cihazların iletişimi daha kolay ve daha güvenli olacaktır. Bununla birlikte, çok sayıda cihazın izlenmesi ve kontrol edilmesi bir problemdir. Bu amaçla, otomatik izleme ve kontrol sistemlerine ihtiyaç vardır. Bu çalışmada, bir yüzme havuzundan pH, serbest klor ve sıcaklık değerlerini ölçmek ve bu verileri uzak bir sunucuya aktarmak için bir cihaz geliştirilmiştir. Ayrıca, nesnelerin interneti cihazları için kural tabanlı izleme yazılımı geliştirilmiştir. Geliştirilen yazılımla, cihazdan elde edilen veriler için kurallar tanımlanmakta ve bu kurallara göre uyarılar verilebilmektedir. Benzer şekilde, belirli bir görevi yerine getirmek de mümkün olabilir (örneğin, bir kurala bağlı olarak pH dengesi için gerekli kimyasalları sağlayan bir cihazın çalıştırılması). Geliştirilen yazılımla farklı cihazlardan alınan veriler için kurallar tanımlamak ve bu kurallara göre görev tanımlamak da mümkündür.

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## Rule-based monitoring system for Internet of Things (IoT) device

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### ABSTRACT

More and more devices are being developed every day to make life easier. Most of these devices can be controlled and remotely monitored by integrating into existing systems or deploying as new systems. With the IoT era, devices will be easier and more secure to communicate. However, monitoring and controlling of large numbers of devices is a problem. For this purpose, there is a need for automated monitoring and controlling software. In this study, a device has been developed for measuring pH, free chlorine and temperature values from a swimming pool and transferring these data to a remote server. Also, rule-based monitoring software for IOT devices has been developed. With the developed software, the rules for the data obtained from the device are defined and warnings can be given according to these rules. Similarly, it may also be possible to fulfill a certain task (e.g. the operation of another device that delivers necessary chemical for pH balancing) as a result of the rules. It is also possible to define rules for data received from different devices with the developed software and to define tasks according to these rules.

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### 1. INTRODUCTION (GİRİŞ)

Developing information and communication technologies have enabled applications that have not been possible before, such as communication of machines with each other, remote monitoring and control in real time

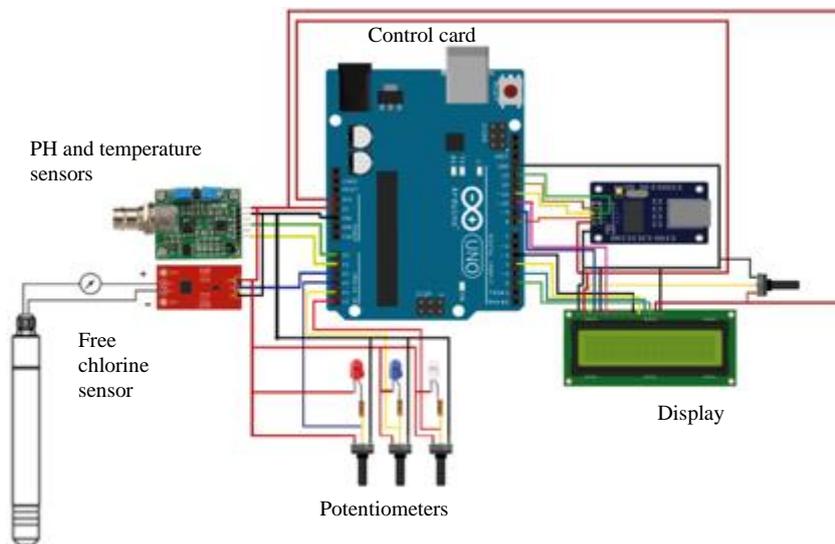
[1]–[3]. These changes with the development of technology will continue to make our lives easier. This allows us to remotely control the devices we need. E.g., we can control the temperature setting of our air conditioner by using the outside air temperature. Or, as in the case of this study, the quality of the water can be checked using the instantaneous PH, Free Chlorine, and temperature values of a swimming pool. All these developments led to the emergence of the concept of Internet of Things (IoT). One of the necessities of the IoT is that the devices can be connected, monitored and controlled without the need for any external intervention [2], [4]–[6]. Devices must have plug-and-play capabilities to ensure connectivity [7]–[9]. Automatic monitoring and control software systems with rule-based or artificial intelligence support are needed to meet monitoring and control requirements [10]–[12]. Without these requirements, it is not possible to develop a scalable *network*. We have addressed the requirement of automatic monitoring and control software systems. In this study, we developed a software that enables an IoT device user to define rules for devices, and enable to evaluate the data received from the devices with these rules. We also developed a device that can monitor the water quality of swimming pools with PH, Free Chlorine and Temperature parameters.

The rest of paper is organized as follow: Section 2 gives the materials and methods. The results are given in Section 3. Section 4 concludes the paper and discusses the results.

## 2. MATERIAL and METHODS (MATERİYAL VE YÖNTEMLER)

The developed device instantly measures the PH, Temperature and Free Chlorine values of the swimming pool water, checks the compliance of these measured values with the required rules and saves the measured values to the database. The device informs the user if the measured values do not comply with the required rules. In this section, we will explain in detail the features of the device and software we developed.

*Hardware*s Arduino Uno - is an open source microcontroller board. It was used as the control card of the developed device. Ethernet Module – It is used as the network interface of the control card. Current Sensor - Since the Free Chlorine sensor measures the current it produces, the current sensor is used. LCD Display - used to display control card warnings. PH and Temperature Sensor - used to measure PH and temperature values of pool water. Free Chlorine Sensor - used to measure the free chlorine value of pond water. General diagram of the developed device is shown in the Fig. 1.



**Fig. 1.** Overall scheme of the developed device.

*Rule-Base* Many new methods and technologies have been developed in order to give similar skills such as logic and reasoning to computers and other smart devices. One of these methods is rule-based systems. Rule-based systems are one of the techniques commonly used in the development of expert systems. The rules are composed of two parts, “if” and “then”. In this programming approach, rules are defined as a set of tasks that must be done

for a given situation. They are based entirely on human experience. The “if” part of the rule is the part of the statement that defines the event or data that makes the condition available. Associating states to defined patterns is called statement association. The “then” part of the rule is the part that determines the operations that will run when the rule is applicable. The inference mechanism first selects a rule and then the operations of the selected rule are executed. Then, another rule is selected and its operations are executed. This process is continued until there is no applicable rule. An example rule for the developed device is as follows. In the following rule, it is checked whether the PH, temperature and free chlorine values are within the predetermined ranges.

```
If      (ph > MINph and ph < MAXph) and
        ( temperature > MINtmp and temperature < MAXtmp) and
        (chlorine > MINchl and chlorine < MAXchl)
Then    Pool's condition is fine.
```

*Software – Setting the Rules* Rule entries can be made either directly from the device or via the developed interface software. In the circuit in Fig. 1, rule entries can be made via potentiometers. Since instantaneous measurements cannot be consistently the same, a certain tolerance values have been determined for each parameter. Tolerance values are given in Table 1. Example of a rule entry is shown in Fig. 2.

Table 1. Tolerance ranges of the device

Parameter	Tolerance range
PH	+/- 1 ph
Temperature	+/- 3 °C
Free Chlorine	+/- 0.5 ppm



Fig. 2. Setting rules by using potentiometers (klor means free chlorine)

The second way of entering the rule is the method made through the developed software for the device. In this way the tolerance value is not required. By entering the desired measurement ranges, measurement is provided. The entered ranges are considered as rule entries and an undesired measurement occurs when a measurement is made outside these ranges. In case of unwanted measurement, necessary warning messages are transmitted to the user with the device and the developed software.

*Software – Outputs* If any irregular measurements are made after entering the rule on the water quality monitor, warning conditions will occur. The device warns in three different ways when an illegal measurement is taken: via interface software, with a web browser via an Ethernet module, via a web browser, via Twitter. For example, a tweet for the warning is shown in Fig. 3.



Fig. 3. Sample warning tweet

### 3. EXPERIMENTAL RESULTS (DENEYSEL SONUÇLAR)

During the experiments, we used water with known pH and temperature. The developed device has been measured according to the references. The developed device allows the addition of different sensors to measure new parameters. Sure, this is limited to the maximum number of inputs allowed by the controller. There are some issues that need to be considered during the installation of the device. When connecting the chlorine sensor to the circuit of the device, the required voltage values (depending on the brand of the sensor used) are supplied to the sensor and the sensor is integrated into the circuit by connecting to the current sensor. In order to make a reliable measurement of the chlorine sensor connected to the device circuit, the water must have a certain flow speed. The device is connected to a computer with the current state. Database and rule base software is kept on this computer. This simplifies the design but increases the cost. By using a microcomputer class card as a control card, the computer requirement can be eliminated.

The developed device can tweet when an exception occurs. As a rule of Twitter, a user cannot send two tweets whose content is exactly the same. Therefore, the day and time must be included in the tweets.

### 4. CONCLUSION (SONUÇ)

In this study, a device has been developed to measure pH, free chlorine and temperature values from a swimming pool and transfer this data to a remote server. In addition, rule-based monitoring software has been developed for IoT devices. With the developed software, rules can be defined for the data obtained from the device and warnings can be given according to these rules. Similarly, it may be possible to perform a particular task (for example, operating a device that provides the chemicals necessary for pH rate based on a rule). Essentially, it is possible to control many devices with the rule-based approach. The operation of an air conditioner / heater and the operation of indoor air quality controllers are similar. In addition, by converting the Internet architecture of the objects used to cloud architecture, multiple devices and sensors can be used at the same time and the measured values can be controlled by creating a network between devices. By creating an inter-device cloud system, the devices can be easily communicated regardless of the distance between them.

### Publication Ethics Statement (Yayın Etiği Beyanı)

The abstract of this study has been presented in The Proceedings of International Symposium on Industry 4.0 and Applications (ISIA 2017), 12-14 October 2017, Karabük University, Karabük, Turkey.

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