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INTERNET CONTROLLED SMART TEA MACHINE DESIGN WITH ARDUINO AND TEA CONSUMPTION ANALYSIS

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ABSTRACT: In this application study, a device that put the data on the tea brewed using the smart tea maker on the internet employing the Arduino development board has been developed. Furthermore, a web interface that analyzes the data collected and informs the user has also been developed. The device comprises the sensors located on the teapot and water boiler chamber and the Arduino Mega development board with a WI-FI module that controls these sensors. The sensors receive data on the amount and temperature of tea and water and the brewing process. In the web interface, the data collected from the device is recorded on the SQL Server database. Analyzing the data, the amount of tea consumed in the establishment (daily, weekly, monthly), the time periods when tea consumption peaks within the day and the amount of left-over tea are reported. Besides that, the estimated brewing process is displayed to the user via the interface. Implementing this study, it is planned to facilitate the estimation of the performance range by analyzing values and time periods of tea consumption of the personnel in the establishment. This will also contribute to the reduction of tea consumption expenses in the establishment.

Keywords: Arduino, Analysis, Internet of Things, Tea Machine.

ARDUİNO İLE İNTERNET KONTROLLÜ AKILLI ÇAY MAKİNASI TASARIMI VE ÇAY TÜKETİM ANALİZİN YAPILMASI

ÖZET: Bu uygulama çalışmasında, Arduino geliştirme kartını kullanarak akıllı çay makinesinde demlenen çay verilerinin internete aktarılmasını sağlayan cihaz geliştirilmiştir. Ayrıca alınan verileri analiz eden ve kullanıcıyı bilgilendiren bir web arayüzü tasarlanmıştır. Cihaz, çay makinesinin demlik ve su kaynatma haznesine yerleştirilen sensörler ve bu sensörleri kontrol eden Wi-Fi modüllü Arduino Mega geliştirme kartından oluşmaktadır. Sensörler, çayın demlenme durumu, miktarını, sıcaklığını, suyun sıcaklığı ve su miktarı verilerini almaktadır. Web arayüzünde, cihazdan gelen veriler SQL Server veri tabanına kaydedilmektedir. Bu veriler analiz edilerek, kurumun zamana bağlı (günlük, haftalık, aylık) çay tüketim miktarı, gün içerisindeki çay tüketim yoğunluk dilimleri ve tüketilmeyen çay miktarı raporlanmaktadır. Ayrıca çayın tahmini demlenme durumunu kullanıcıya arayüzden göstermektedir. Çalışmanın uygulanması ile kurum içerisindeki personelin çay tüketim değerleri ve zaman dilimleri analiz edilerek, iş performans aralıklarının tahminine yardımcı olması planlanmaktadır. Ayrıca kurumun çay tüketim giderlerinin düşürülmesine katkı sağlanacaktır.

Anahtar Kelimeler: Analiz, Arduino, Akıllı Çay Makinası, Nesnelerin İnterneti.

1. INTRODUCTION

The reflection of the fast-moving technology on the electronics and automation has brought the fast-processing development boards with high stability in its wake [1]. That being said, programming the microprocessor and the microcontroller on the development boards became more convenient [2]. The fact that development boards are controlling and interpreting electronic systems online created the notion the internet of things. Many electronic systems used in daily life is controlled online. Therefore, development boards are highly opted for in the internet of things model [3].

In the study; using the internet of things model, the data taken from the tea is transmitted and interpreted in the web environment. The Designed model device is stored in the SQL Server 2008 database, retrieving the amount of brew and water from the teapot. Data is processed with formulas and daily, weekly and monthly consumption values are obtained. These results are provided to assess the values of the institution's tea consumption. Consequently, the institution aims to contribute to the reduction of expenses of tea consumption.

2. BACKGROUND

2.1. Arduino Development Card

Arduino is an open source hardware and software microcontroller development card that enables the control of electronic systems in the internet world of objects [4]. There are 37 different types of Arduino development cards, depending on their usage area and abilities. The main purpose of the Arduino is to interpret and control the sensors and systems via input-output pins.

Arduino development card first started to use with UNO version. This version has an ATmega328 microcontroller with 14 digital 6 analogue inputs [5]. Different Arduino varieties have been produced along with the developing needs. In most of the comprehensive projects carried out, Arduino mega development card with 54 digital 16 analogue inputs is used [6]. Arduino development cards can work stable between 5 and 20 volts. To install the software on the Arduino development board, you need to use the Arduino IDE software. Programming with bootloader is possible without the need for an external programming card.

2.2. MZ80 Infrared Sensor

The MZ80 infrared sensor is used on the Arduino development card to find the distance of objects between 3-80 cm. This sensor can react at 2ms by pulling 10mA current [7].

2.3. ESP 8266 Wi-Fi Shield

ESP8266 is one of the modules used to provide internet access in systems implemented with Arduino development card. There is an internal antenna via the ESP8266 WI-FI module. In this way, data packets can be sent and received via the TCP / IP protocol [7].

3. THE STUDY

The realized study is composed of two parts as shown in Figure 1. In the first part, the sensor-fitted control box and software, which transfer the data required for tea analysis, were developed. The control box records the data collected by the sensors on the water and brew chambers of the tea maker via WI-FI to the database once in every hour. In the second part, the data received from the system was stored and interpreted. The data coming from the control unit is interpreted in terms of consumption and time and conclusion are made.

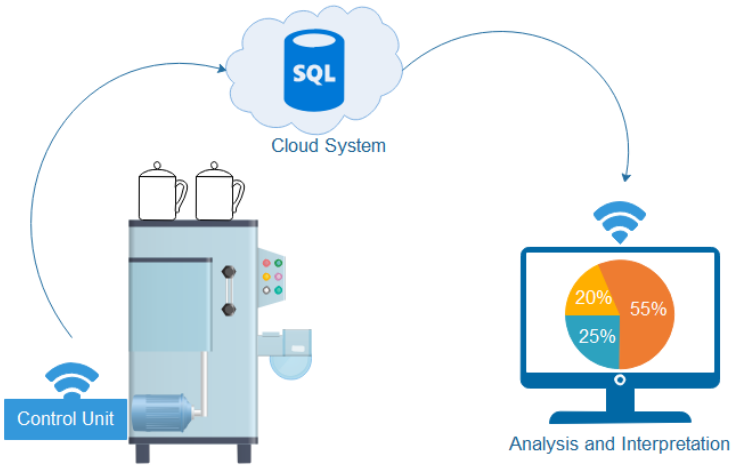


Figure 1. Smart teacup working model.

3.1. Designing System

In this part, the control unit, which makes sure that the data is received from the sensors on the water and brew chambers of tea makers and recorded on the database, was developed. There are a heat sensor for calculating the temperature and an IR sensor to estimate the water level in the teapot and water chamber of tea makers. Arduino Mega development card is utilized in order to receive instant data from these sensors. The data is received once in every hour through the Arduino development board. The Arduino development board employs the WI-FI module for transferring the data received to the database. The circuit diagram of the system is presented in Figure 2.

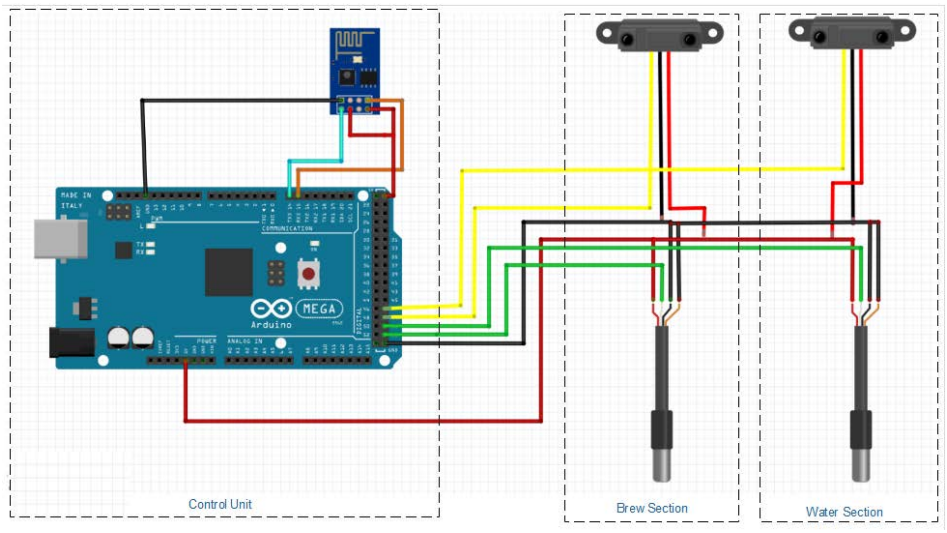


Figure 2. System control unit circuit diagram.

3.2. Software Development

A software was developed for the Arduino development board and the control unit to receive data periodically from the sensors and to transfer them to the database via WI-FI. Software's can be uploaded on the Arduino development board using the Arduino IDE. In the first section of the software, necessary identifications were made for the communication between the Arduino and the sensors (Figure 3).

```
int teapot_temp;
int teapot_level;
int water_temp;
int water_level;
#define pin_temp1;
#define pin_temp2;
#define pin_level1;
#define pin_level2;
```

Figure 3. Making definitions.

In order to be able to transfer the data received from the sensors to the database, the WI-FI module must have internet connection. The WI-FI name and password have to be identified, so that the WI-FI connection is established for the Arduino and the WI-FI module as shown in Figure 4.

```
int status = WL_IDLE_STATUS;
char ssid[] = "a2swifi";
char pass[] = "123457";
int keyIndex = 0;
```

Figure 4. Wi-Fi network and password definition.

In order to be able to estimate the approximate brewing time and send an SMS to the user, the water temperature has to be above 60 degrees and the water level has to be at maximum. When these conditions are met, the system waits for 15 minutes. When the code block waiting time shown in Figure 5 is over, a message that reads as "Tea is ready." is sent to the user interface.

```
if(((millis()-start_time)/ 60000) == 15)
{
 String parameters="Result=Tea is Ready";
   if (client.connect("smarttea.ar-gem.net", 80))
    {
           Serial.println("connected to server");
           client.println("GET /?parameters HTTP/1.1");
           client.println("Host: smarttea.ar-gem.net");
           client.println("Connection: close");
           client.println();
     }
}
```

Figure 5. Sending the infusion message to the user interface.

The control unit has to convey the data transmitted by the sensors to the service in the server as parameters after it is connected to the internet. A variable called parameters is created for this operation. The data on temperature and level is combined into a single parameter and then transferred to the database. The code block that ensures the transfer of data to the server is presented in Figure 6.

```
if (client.connect("smarttea.ar-gem.net", 80))
{
  Serial.println("connected to server");
  client.println("GET /?parameters HTTP/1.1");
  client.println("Host: smarttea.ar-gem.net");
  client.println("Connection: close");
  client.println();
}
```

Figure 6. Sending parameter to server.

The data received from the smart tea maker is recorded on the database in the server through the WI-FI module once in every hour. The data is conveyed to the server in link format as shown in Figure 7. The parameters are received via ASP.NET and they are separated to be added to the SQL Server database whose table structure is shown in Figure 8.

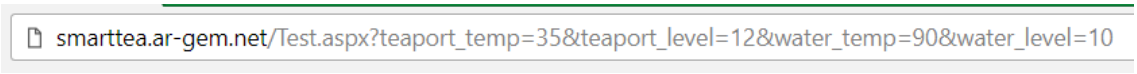
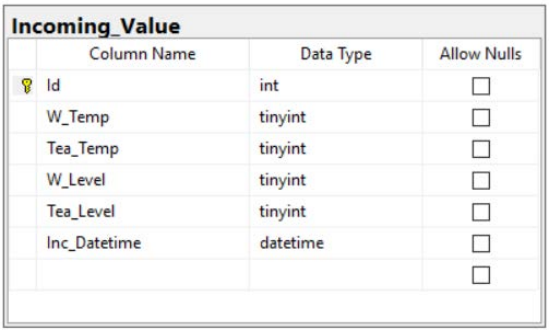


Figure 7. Sent parameter address.



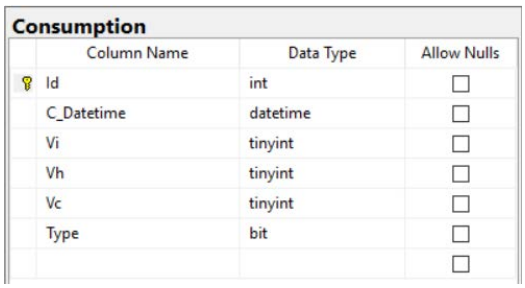
Incoming_Value

Column Name	Data Type	Allow Nulls
Id	int	☐
W_Temp	tinyint	☐
Tea_Temp	tinyint	☐
W_Level	tinyint	☐
Tea_Level	tinyint	☐
Inc_Datetime	datetime	☐
		☐

Figure 8. The table structure where the values received at first are stored

3.3. Processing Received Data

The data received from the smart tea maker is kept in the table shown in Figure 8. These data has to be processed, so that it can be interpreted. The processed values are kept in the table within the database shown in Figure 9.



Consumption

Column Name	Data Type	Allow Nulls
Id	int	☐
C_Datetime	datetime	☐
Vi	tinyint	☐
Vh	tinyint	☐
Vc	tinyint	☐
Type	bit	☐
		☐

Figure 9. The table structure where the processed values are stored.

3.3.1. The calculation of the amount of consumed brew

In order to calculate these values, the difference between the values received once in every hour and the first value is estimated. The consumption value is calculated by proportioning the difference and the total chamber volume. The consumption values estimated once in every hour can be calculated on a daily, weekly and monthly basis.

The Equation 1 is used for calculating the initial volume of the tea in the teapot. V_{ti}, h_{ti} and r signify the initial volume, the level value received from the sensor and the radius of the teapot respectively.

$$\mathbf{V_{ti}=\pi r^2\, h_{ti}} \quad (1)$$

The Equation 2, on the other hand, is used for calculating the hourly consumption level of the brew in the teapot (V_{th}) according to the level values (h_{th}) received from the sensor once in every hour.

$$\boldsymbol{V_{th} = V_{ti} - \pi r^2 h_{th}} \quad (2)$$

The Equation 3 is used for estimating the remaining brew (Vtc) at the end of the day.

$$\boldsymbol{V_{tc} = V_{ti} - (\sum_x^y V_{th})} \quad (3)$$

x: Start of time
y: End of time

3.3.2. The calculation of the amount of consumed water

The amount of consumed water in the water chamber is calculated using the information on chamber's volume and level data.
The Equation 4 is used for calculating the initial volume of the water in the water chamber. V_{wi} and h_{wi} signify the initial volume and the level value received from the sensor respectively.

$$\boldsymbol{V_{wi} = W_a W_b\, h_{wi}} \quad (4)$$

Wa: Long sides of the water reservoir
Wb: Short sides of the water reservoir

The Equation 5, on the other hand, is used for calculating the hourly consumption level of the water in the water chamber (V_{wh}) according to the level values (h_{wh}) received from the sensor once in every hour.

$$\boldsymbol{V_{wh} = V_{wi} - W_a W_b\, h_{wh}} \quad (5)$$

The Equation 6 is used for estimating the remaining water (V_{wc}) at the end of the day.

$$\boldsymbol{V_{wc} = V_{wi} - (\sum_x^y V_{wh}} \quad (6)$$

x: Start of time
y: End of time

4. RESULT

In order to analyze the processed data, the values on the database are transferred to the interface. The daily, weekly and monthly diagrammatic representations of the amount of consumed brew in the smart tea maker are shown in liters in Figure 10. The daily consumption diagram shows that the consumption levels increase during noon hours. The weekly consumption is 37.74 lt in total and the average is 7.54 lt. When the analyses are examined on a monthly basis, the total consumption amounts to 161.22 lt.

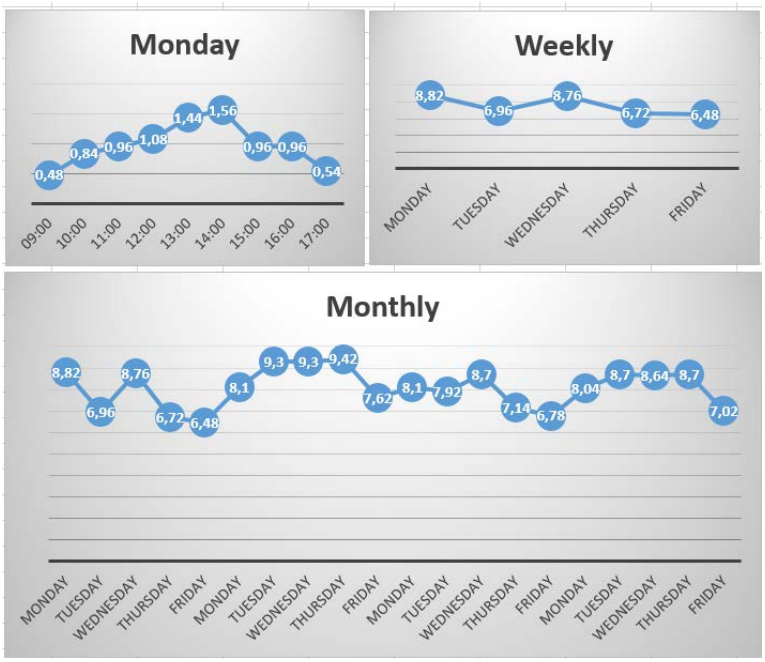


Figure 10. The diagram of daily, weekly and monthly brew consumption.

The daily, weekly and monthly diagrammatic representations of the amount of consumed water in the smart tea maker are shown in liters in Figure 11. According to these diagrams, daily average water consumption is 18 lt and weekly and monthly water consumption figures in total are 88.06 lt and 376.18 lt respectively.

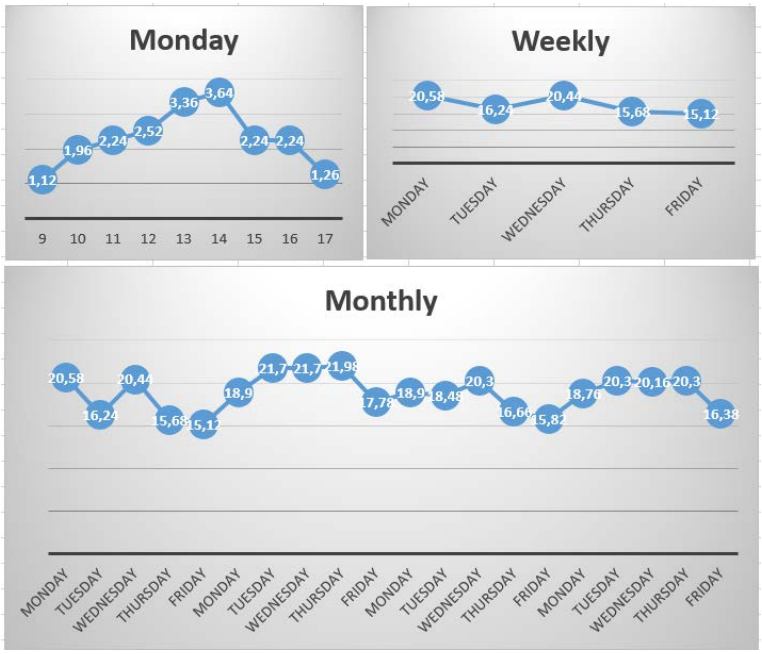


Figure 11. The diagram of daily, weekly and monthly water consumption.

Volume of a standard tea cup is 200 ml. A cup of tea consists of 30% brew and 70% water. In the light of these data, diagrammatic representation of daily, weekly and monthly consumption is shown in Figure 12 in term of tea cups. When the consumption values are analyzed in terms of tea cups, it is concluded that 134 cups of tea are consumed daily on average and 2687 cups of tea are consumed monthly in total.

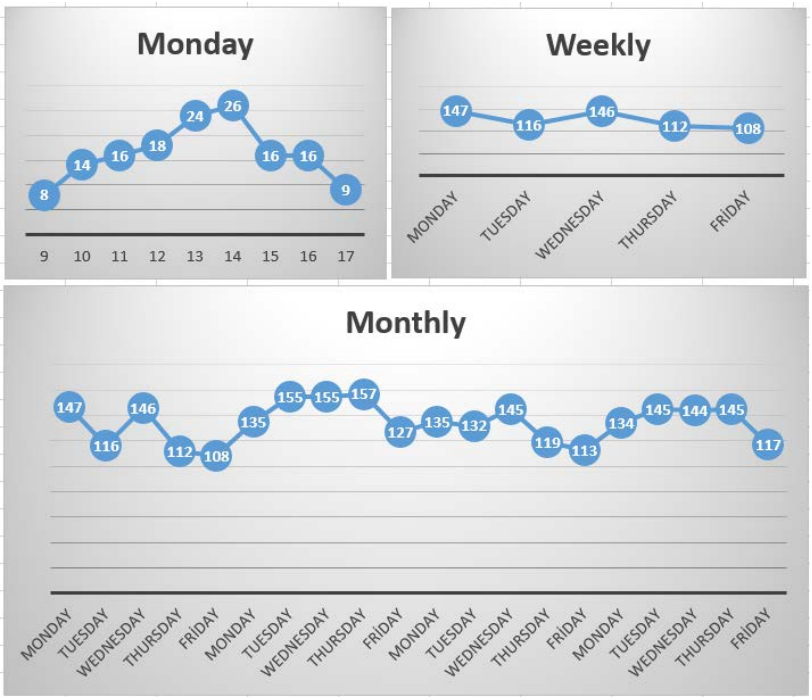


Figure 12. The diagram of daily, weekly and monthly tea consumption.

The monthly tea consumption analysis showed that the total amount of tea brewed monthly was 210 lt. On the other hand, the consumed and remaining brew amounts are compared in Figure 13. According to the consumption results, a total of 161.22 lt brew was consumed during the month. However, 48.78 lt of brew was not consumed. Taking these results into consideration, approximately 23.22% of the brewed tea runs to waste.

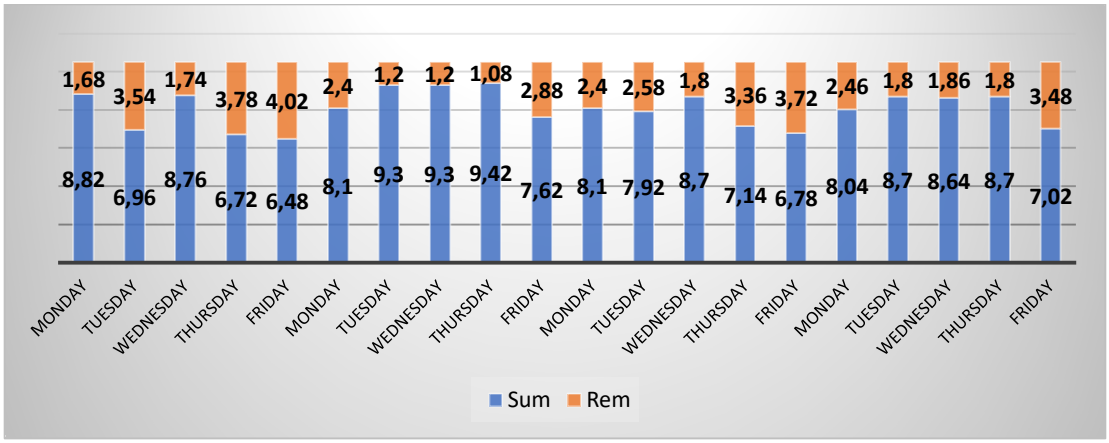


Figure 13. Comparison of the amount of meat consumed and brewed.

5. CONCLUSION

The system was utilized for a month for testing the smart tea maker and collecting data. During this period of time, the data collected by the sensors was recorded on the database once in every hour by the system. Raw data collected was processed using the determined equations. As a result, processed data was used for providing the diagrammatic representations in the developed interface.

Implementing this study, it is planned to facilitate the estimation of the performance range by analyzing values and time periods of tea consumption of the personnel in the establishment. Moreover, the amount of remaining brew was calculated in order to find out the monthly amount of remaining brew. In the light of these data, it is aimed to contribute to the reduction of tea consumption expenses in the establishment.

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