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SMART CLOUD BASED ECOLOGICAL SYSTEM FOR CONTACTLESS VEHICLE CLEANING

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A B S T R A C T

The rise in the overall standard of living leads to an increase in the number of used cars. As the number of cars increases, so do the maintenance requirements. As a result, the growth of vehicle washes is increasing. However, the issue of their economy comes up. The current literature sources present the following ecological and technical issue: how to determine and apply the best use of water and detergent on automated car washing systems while minimizing vehicle washing time. Thus, this paper tries to propose a ecological contactless vehicle washing smart system based on the application of cameras, programabile logical units and cloud database for high-quality vehicle washing, monitoring and optimal resources usage. Specifically, the proposed smart system for automatic contactless vehicle washing could be used for water flow regulation, detergent concentration regulation and for managing the process of determining the overall dimensions of the vehicle.

1. INTRODUCTION

The majority of vehicle washing systems currently available rely on human labor. This type of car wash has a variety of flaws, including poor washing, lengthy wait times, and excessive water and cleaning product usage (Lalluwadia et al., 2017). To solve these challenges, a number of automatic car-washing systems have been created in recent times, based on the use of RFID-GSM (Vidyasagar et al., 2015), programmable logic controller (PLC) and SCADA (Alphonsus et al., 2016; Lalluwadia et al., 2017), proximity sensors (Gaikwad et al., 2017).

However, in most cases the in process of car washing, systems used a fixed amount of water and detergent, regardless of the level of dirtiness of the car, which leads to an ecological unoptimised waste of resources and larger costs. For vehicles with a low degree of soiling, the fixed amount of water and detergent used may be too high, which leads to their wastage and more difficult washing (Genuino et al., 2012). On the other hand, for vehicles with a high level of dirt, it can be low, which leads to poor cleaning results.

In addition, in automated car washes that use the movement of the mechanical arm assembly and the jet

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or spray of water and detergent for cleaning and washing the vehicle, it is very important to correctly determine the overall dimensions of the vehicle being cleaned (Chrysalidis & Kyzas, 2020). It is a procedure that requires a significant amount of time spent in the vehicle washing process. An ultrasonic sensor is used to determine the length of the vehicle in automated car washes every time they enter, the application of which requires a certain amount of time (Saá et al., 2020). The ultrasonic sensor is located on the assembly of the mechanical arm, which, after the vehicle takes the washing position, determines its dimensions in the first pass around the vehicle (Fleming, 2008). The ultrasonic sensor is connected to a PLC and transmits the dimensions of the vehicle to it. Based on the passed dimensions, the PLC device determines the further position of the mechanical arm assembly and defines the further movement around the vehicle being washed. The procedure is repeated every time the vehicle enters the car wash, requiring a considerable amount of time for each wash.

The aforementioned problems are the reason for the development of a system based on the application of cameras and a PLC with a hardware accessory for high-quality vehicle washing, and the desired characteristics with a number of additional advantages.

The proposed smart system for automatic contactless vehicle washing could be used for water flow regulation, detergent concentration regulation and for managing the process of determining the overall dimensions of the vehicle.

2. LITERATURE REVIEW

There are currently two basic types of car cleaning techniques in use. Car washing is a viable solution. The alternative is a mobile car wash service (Zhong et al., 2017). The first service is customer-driven, in which the consumer brings their vehicle to the store to be washed. Typically, a water line, a high-pressure spray pistol, and towels are all that is required to clean a vehicle. Hybrid design that combines automatic and manual car washers are used for a more complex, semi-automatic approach of cleaning automobiles (Ham et al., 2006). Time is the most major disadvantage of hand car cleaning. This is especially true during traffic congestion.

With the advent of Internet of Things (IoT) and car-to-car communication came the "internet of vehicles" (Gerla et al., 2014), ushering in the age of the autonomous automobile. Elevator internet (Yang et al., 2016) is the result of the interconnection of elevators with the IoT, allowing for the first time to perform intellectualized elevator maintenance. The car wash sector is leveraging technologies from the IoT and big data to build a car wash cloud and terminal interface that connects cloud operators with car-wash shops, and car-wash manufacturer representatives with customers. The driver can take use of the automatic car-washing service at any time and from any location by visiting the nearest car-washing store. To put it simply, cloud operators are the ones in charge of building and maintaining the system. Manufacturers in response to various models will make functionality enhancements (Gerla et al., 2014). Safe, quick, convenient, and environmentally friendly automatic car washing service is provided by the shops, all of which have well-maintained car wash equipment.

The IoT as an emerging paradigm in ubiquitous computing built from the ground up on the internet (Wu, 2015), uses both wired and wireless networks to connect to the Internet. It achieves real-time, everywhere connectivity between things, objects, and people by employing synthetic mass sensors, an intelligent processing terminal, and global positioning system technology (Arsénio et al., 2014). When all is said and done, it achieves smart management and command. There is the widespread implementation of IoT applications like internet of vehicles, unmanned aircraft, automatic car washer (Gaikwad et al., 2017) and etc. Thus, has caused some to refer to it as the "third wave" in the global information business, following the computer and the internet (Zhong et al., 2017). This style of automatic car washing has a variety of specific uses, including a mass automatic car washer, video security cameras, access through mobile devices, and vehicle identification.

Therefore, in this age of the IoT, automatic car washing mode is not only an unavoidable consequence of technical progress but also a selling point (Rosenbloom, 2000). Thanks to the unified cloud platform, mobile terminals, video security cameras, and mass-produced automatic vehicle washers may all connect with one another. Meanwhile, transaction and client information is recorded. As a group, the merchants maintain their individual customers. Customers can have their vehicles cleaned at the most convenient location, regardless of where they are parked. This procedure ensures quality and lowers vehicle washing time. There will be fewer individuals hand-washing automobiles and more customers at car wash services. Different consumers can choose to retain the original, exquisite cleaning or inspection procedure.

In the paper by Vidyasagaret et al. (2015), authors discussed the usage of a microprocessor to manage the automatic car washing process. They explained how to employ a wide range of IR sensors, RFID equipment, and GSM networks. A conveyer mechanism is used to move the car from the garage door to the garage worker's station. A sensor that can detect dust particles can pinpoint the area of the car where dirt has settled. A sprinkler and drying system are utilized to clean the car. In order to prevent unintentional car detection, RFID could be utilized in conjunction with GSM technology. Meanwhile, GSM could be used to keep customers updated on the cleaning status of their vehicles.

The electro-mechanical method for operating an automatic car washing was presented by Tejas et al.

(2017). Automatic car washers use a device that raises parallel cars and moves forward to wash them. The vehicles are then washed in a sequence of foam water, soap, water, and clean water. The vehicles are raised once more and positioned parallel to the ground. Mechanical assembly and electrical control make up the bulk of the system. The importance of PLC in operating vehicle washers is emphasized.

The paper by Sorkhabiet et al. (2014) explains how a PLC is used in an automatic smart car washing. The smart car washing can automatically adjust its size to accommodate any vehicle. The dimensions of the vehicle are significant in adjusting various elements such as the position of the cleaning brush and the time duration. This automation improves speed, accuracy, productivity, and safety while decreasing washing time and cost.

3. SYSTEM DESCRIPTION

In view of the above, this paper tries to present a system for automatic car washing that can, by applying modern technologies, determine the optimal amount of water and concentration of detergent according to the degree of soiling of the vehicle body, while reducing the washing time. The mentioned issues were eliminated by the use of industrial cameras, ultrasonic sensors, a mechanical arm mechanism, a nozzle, a water tank, a detergent tank, a hose for water flow, a hose for detergent flow, a control valve for regulating the water flow and a control valve for regulating the flow of detergent that serve to inflow of water and detergent at the location where the vehicle is washed, and a programmable logic unit with a hardware accessory (Figure 1).

One of the cameras are used for vehicle identification through license plates. If the vehicle entered the car wash for the first time, the ultrasonic sensor is activated to determine the length of the vehicle. The information about the specific length of the vehicle is stored in the database, so that this information is automatically available every time the vehicle enters the car wash and its license plate is detected. The vehicle length information obtained from the database affects the control of the mechanical vehicle wash arm assembly, reducing the time required to determine the length using the sensor. Another camera records the dirty surface of the car and is used to determine the level of dirtiness of the vehicle body. The information system is used to control the water and detergent flow valves based on the images formed by the cameras according to the degree of soiling of the vehicle body, so that the optimal amount of water and detergent mixture is sent to the mechanical arm assembly for washing the vehicle. Based on the level of contamination, it is possible to define the flow rate, the length of the open time or the number of active high-pressure nozzles. Therefore, the level of detergent and water usage is matched to the vehicle's soiling.

The cameras work via the GSM network, i.e. a sim card goes into it like a cell phone. Every SIM card has its own IP address, just like every computer. Through that IP address, you can see what is happening in the area where the camera is installed at any time from any computer that has access to the Internet. When you connect to the camera, the camera sends a frame to your computer every 5 seconds. In addition, the camera has the possibility of connecting a motion sensor or a door opening sensor, whereby if someone enters the space where the camera is installed, it records a video length as long as it is set on the camera itself and sends it to you by e-mail or saves it on the memory card in the camera (Micro SD card is an accessory), and by connecting it to the camera, you can view the data stored on it. The camera has the ability to record on call, that is. by dialing the phone number that is in the camera, the camera records a video that is also saved on the memory card or sent to e-mail. This function is used if you do not have motion sensors and you suspect that something is happening in the area where the camera is placed and you do not currently have a computer near you.

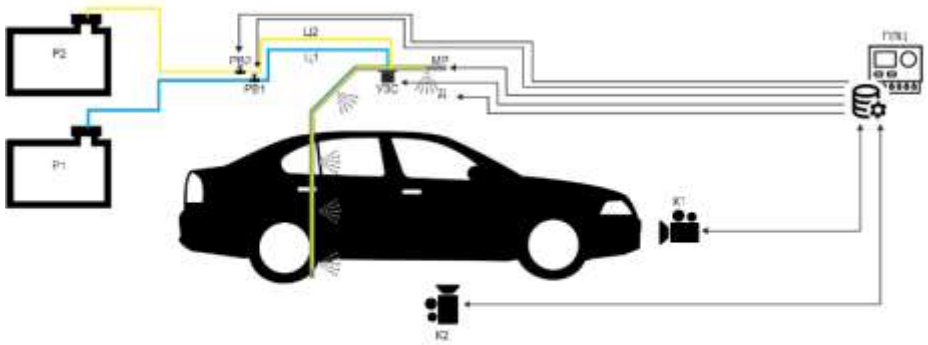

Figure 1. Solution proposal for a smart car wash system

The software for monitoring and managing Smart automatic car washes was created using JavaScript and PHP scripting languages and the Arduino library for C and C# programming languages (Figure 2). The software consists of three main components. The first component is used to collect data from Smart automatic laundries and was implemented using the PHP scripting language and the Arduino library for programming languages C and C#. The second component is a database component in which data is stored in the form of an object-oriented database, that is, in the form of JSON documents. The third main component is the user interface, which is implemented using the JavaScript open source library. The data is collected from the automated laundries using the first component and forwarded to the second component via the GSM module. The data is then stored within another component and can be used as a control trigger through the GSM module for sensors that will reduce the water flow through the electric valve or reduce the flow time or reduce the number of active nozzles of the automated laundry. Finally, data on resource consumption can be displayed to users with different privilege levels within the third component of the realized software solution, that is, the Corinthian interface.

Figure 2. Information system concept

It was established that after logging in the user via the login screen, which is a navigation screen in the background, based on privileges (limited number of functionalities), laundries that need to be monitored can be selected in the user part of the application.

The application allows the user to get a graphic display of the values of the following parameters for a time interval:

1- Number of washes

2- Water consumption (Parameter 1)

3- Consumption of shampoo or detergent (shampooing) (Parameter 2

4- Wax consumption (waxing) (Parameter 3)

The selection screen for the level with administrator privileges provides additional features and functionality. The administrator has privileges over the data of all users and the laundries available to them. At the prototype level, the functionalities that are available are related to the basic data of customers of laundromats, users of the system, laundromats with their location, car brands and models, colour catalogs, etc.

The details of the physical scheme of the part of the database related to data storage of measured values of parameters such as used chemicals, used water, number of washed vehicles, temperature and pressure of automated car washes were defined. Tables of physical schemes contain basic data on the current values of the observed parameters, the time when the parameters were registered and the time of data entry into the database. Picture is attached for temperature and pressure Figure 3.

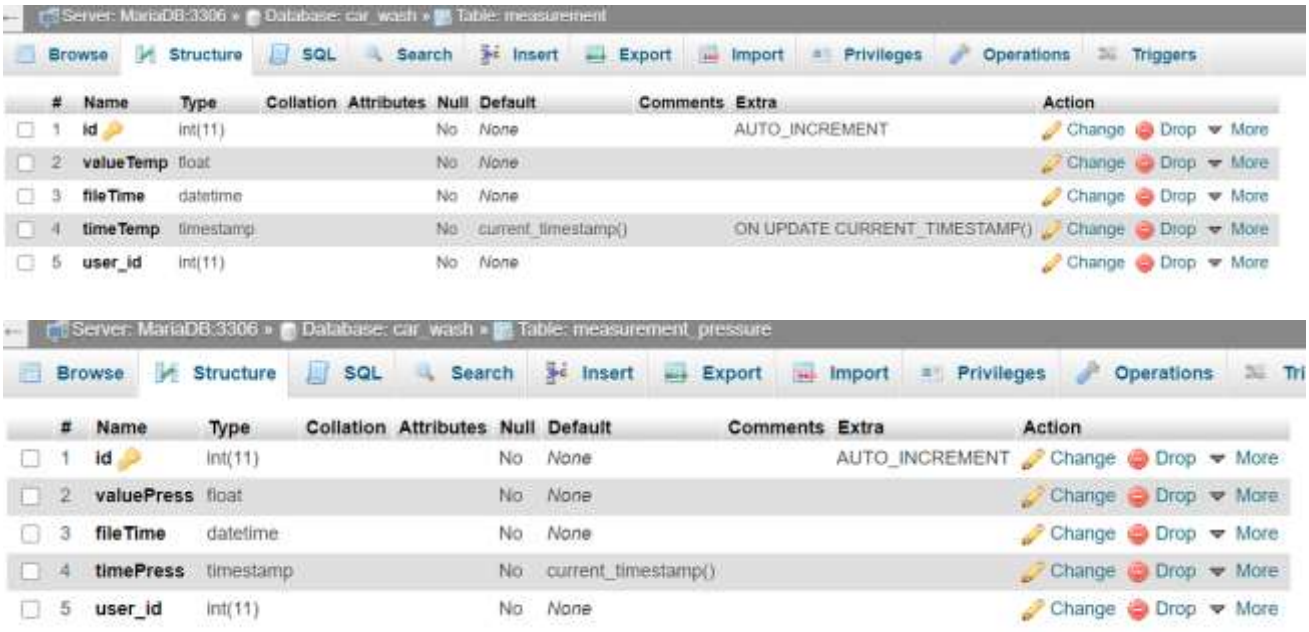

Figure 3. Information system database concept

Realization of the software component of automation of communication using the selected Arduino GSM between the Information System and the main PLC device at the location of the laundry was applied. The basic requirements related to monitoring the temperature using the GSM module and sending SMS messages with information about the temperature to the IS database at certain time intervals were determined.
A sensor is used to measure temperature, pressure, consumption of chemicals, etc. The functionality of the module is shown on the example of temperature. Example: If the measured temperature is higher than 50 ° C, an SMS message is sent to the specified number with the appropriate values depending on the location of the washing station. The values are translated into information that is comprehensible to the IS user (washing station owner) and the IS administrator, on the basis of which further decisions will be made.

4. CONCLUSION

The innovative part of the invention includes the installation of two cameras and a programmable logic unit with a hardware accessory: first camera, which is used to create photos for vehicle identification, and second camera, which is used to record photos with data on the dirtiness of the vehicle body, and a programmable logic unit PLC with a hardware accessory, which is used for storage of data on vehicle dimensions, vehicle identification based on license plates and to determine the level of vehicle dirtiness based on photos recorded by the second camera.

In view of the above, this paper presents an invention that was made as a system for automatic car washing that can, using modern technologies, determine the optimal amount of water and detergent concentration according to the level of soiling of the vehicle body, while shortening the washing time.

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