ON-CLOUD DATABASE AND 3D PRINTING TECHNOLOGIES FOR SMALL SCALE IFV HATCHES MONITORING SIMULATOR

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ABSTRACT: Nowadays, the industry has developed to such an extent that it is increasingly using automatization. This has forced all industries to scale up automatization processes, reaching military industry as well. This project describes a simulator of hatches operated using an Android application based on transmitting data via a cloud database. It allows portability and is accessible from most hand-held devices. The structure in which all the hardware components were assembled is an armored personnel carrier made by 3D printing that was designed in CAD specialized software.

KEYWORDS: 3D printing, wireless, Android, cloud database, simulation.

1. Introduction

Armored personnel carriers are military vehicles that ensure the transport and distribution of military personnel for the conduct of specific operations. Thus, the military industry has developed significantly, coming up with automated systems that give the personnel a much improved reaction time to possible dangers. Starting from this idea, in this work is presented the small-scale simulation of the operation of the hatches of an armored vehicle made with the help of 3D technology. The monitoring and operation of the access elements in the vehicle is carried out both from the distance and from inside the vehicle unit, this being facilitated by the application of Java, made for devices with Android operating system, which for the actuator it communicates with a mobile device that controls and controls the actuators associated with the hatches, and for the monitoring component it synchronizes with a cloud database.

The main component of automated systems is the microcontroller, an electronic structure designed to control a process or interaction with the outside environment. This is also the main component of the system for monitoring and operating the hatches of an armored vehicle presented as part of this work. The condition of portability of the system and of use both inside and outside involved the use of a remote data exchange technology such as Wi-Fi. The transmission of the drive commands and the visualization of the trap status at the user level are carried out through a Java graphics application, exploited in this work by a mobile device with Android. In order to achieve the kinematics necessary to open and close the hatches, servomotors have been used, often found in the automation applications of robotic vehicles (for example, when operating the control surfaces of aero models) and even of robots in general (for example, in the joints of robotic arms). Actuators turn out to be compatible and suitable for automation applications for several reasons, among them high efficiency, silent operation, high power developed in relation to their size, high torque and inertia ratio, as well as low acquisition costs.

In order to remotely control, mobile devices such as Personal Digital Assistant or mobile phones can connect to the Internet, which offers the possibility of monitoring and auditing all changes in the status of the hatches, changes that occur in the basic of data in the cloud, thus ensuring synchronization with low latency both at the level of the application and at the level of the module for transmitting the commands to the servomotors, called ESP32, also used in this paper.

In order to make the prototype, designed and assembled specialized three-dimensional modeling software (CAD – Computer-Aided Design), such as Onshape [5], 3D FDM (Fused Deposition Modeling) printing technology was used. For optimal printing, the standard printing program was used with small changes in the percentage of filling, the type of filling and the speed of printing. More details of the printing process can be found in Table 1. For 3D printing, PLA (Polylactic acid) material was chosen, having the color of the black filament. In order to fix the hatches and wheels on the frame of the vehicle, threaded rods of 3 mm and 4 mm diameter were used, respectively, provided with self-locking nuts for tightening. For fixing and operating the hatches, equipoises with steel rods coupled to the hatch using a cylindrical coupling were used.

Table 1. 3D printing parameters

Denuwell parameter	**Parameter value**
Layer height	0.2 mm
Walls	3
Filling	70%
Type of fill	liso
Support	only on the printing table
Type of support	matrix
The temperature of the printing bed	58°C
Filling speed	70 mm/s
Print head temperature	200°C

Thus, the realization of the project involved multidisciplinary, new, efficient technologies that demonstrate the usefulness in the testing and evaluation phases even of the systems on a real scale, by exploiting either the prototyped component (the vehicle and the small-scale hatches) or the software component (the Android monitoring and drive system), while also offering the possibility of distributing the results via the cloud.

2. State

Among the areas of use of microcontrollers, there is also the automated control of equipment. In order to ensure remote data exchange, the literature lists well-known low-energy solutions, such as Wi-Fi or Bluetooth. They can ensure optimal performance in transmitted from the mobile device and receiving command and control command commands at the level of the development module used in this work. The Android operating systems and the Java programming language for the front-end component represent optimal solutions in the early stages of product development, which require minimal computing resources and very short implementation times. Thus, such a system, based on an Android application, a cloud database and a microcontroller with Wi-Fi connection, provides all the premises for carrying out the proposed research work, which will simulate as faithfully as possible the real conditions.

The microcontroller is a compact integrated projection circuit and optimized to perform command and control functions for certain electronic devices. These components easily integrate into the automation project because they do not impose limitations in terms of memories and possibilities of interference; they integrate ideally in applications where the occupied space, the consumption of resources and the price per unit are critical aspects. The three main roles that define microcontrollers are: they receive input signals from sensors, they interconnect with components with Wi-Fi or Bluetooth communication, they store and process actions and instructions, as well as they apply the processed data to other activities/outputs.

The software component of the microcontrollers consists of a code made using the C++ language in the Arduino development environment and the specific libraries available in the language library. The structure of the code is based on embedded libraries that provide basic functionalities. In order to use the functionalities of the available Arduino terminals, each terminal is defined, associating with it the desired functionalities. The loop function is the most important software component, since it describes the main logical part of the circuit, following a series of instructions.

Development boards that offer compatibility with the Arduino compiler give flexibility in electronic applications, since the interaction with buttons, LEDs, motors, video cameras, GPS units is carried out at minimal cost, this fact is also given by the free application offered by the Arduino developers. These advantages led to the formation of a community of users who made contributions to the distribution of knowledge and the development of the Arduino project in general.

In the literature, programmable embedded components and remote communications with low energy resources are often mentioned in the development of robotic platforms. Thus, [1] a solution is presented to make a robot controlled from short distances by means of voice commands. Communication is provided for Bluetooth. The motors used are DC motors. A. M. Abdulazeez presents in [2] the use of robots in different environments, integrating a series of sensors, as well as a camera for understanding the environment. At the same time, the use of mobile devices in their control is brought up. In [3] the RoboCar robot is presented, which integrates a pe-ration fear sensor to transmit the collected data through a Wi-Fi communication. The control of the engines is carried out by tr-a L298n type H-axle. In the control of the robots, it must be taken into account its components of movement (displacement) that can be achieved in different configurations, such as a steering wheel chassis, a 4-wheel chassis of which two are turners or crawlers. Thus, [4] presents a solution to control the movement of long five-deck robots in order to avoid obstacles and move through narrow spaces.

3. Hatch operation and monitoring simulation

The development of the hatch actuation and monitoring simulator consists in the integration of commercially available computing and communication hardware components, as well as the bad realization through mechanical processing and at the 3D printer of structural components. For the command and control of hatches, code sequences implemented in the C++ language are used in the Arduino compiler compatible with the ESP32 development plate.

To ensure connectivity, the ESP32 must be connected to a Wi-Fi network with internet access, and the mobile device must have internet access. This configuration ensures reduced delay access to the cloud database, where trap states ("closed" or "open") are stored. On the mobile device, the developed Android application is installed, providing access to the control and control buttons of the hatches. The 2D graphics of the vehicle (top view) and the color symbolization of the buttons (red – light, green – dark) ensure that the position of the hatches in relation to the vehicle and their statuses are understood.

3.1 Hardware development

The development of the hardware component system of the vehicle's armored vehicle consists of the integration of 5 servomotors cocked in the ESP32 development module. To ensure the control of the system's on/off start/stop, an ON/OFF button was connected on the vehicle housing, which interrupts the power supply from a group of 3 18650 batteries (3.7V rated voltage) connected in series. At the same time, to signal the synchronization of the Android application and the embedded device with the cloud database, a led indicator was connected to one of the terminals of the development board.

Fig. 1 shows the block diagram of the vehicle hardware component from which the main components are distinguished. The ESP-32 development plate transmits the servo motor actuation controls in the form of transformed analog signals from the message received from the mobile application. This assembly is powered by an external current source with a voltage between 9 and 12V. The power supply used consists of 3 Li-Ion batteries of type 18650 of voltage 3.7V and capacity of 3000mAh. They are connected in series to ensure a vehicle supply voltage of 12V.

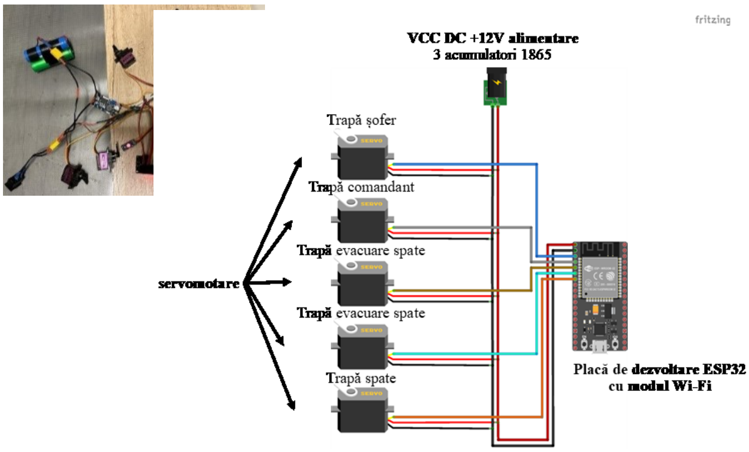


Fig. 1 Block scheme of the hardware component of the system (made using [6]).

The fastening of the components presented above is carried out with the help of 3M dual lock strips on the chassis l vehicle's 3D printed, so as to fit the level of fastening necessary to open/close the hatches. The connection of the hatches with the spin arm of the actuators is made by means of steel rods the length of which is determined in the triangle formed by the point of mounting the spinning arm (coincides with the axis of rotation of the gear wheel of the actuator), the point of attachment of the cylindrical coupling and the tip of the spinning arm, when it is in position "0" (approximately horizontal). For fixing the hatches (see Fig. 2) the threaded rods were used to lie previously by the bore practiced in their body, they also ensure a minimum play of the hatches, but also a rotation with minimal friction in order to avoid overloading the actuators.

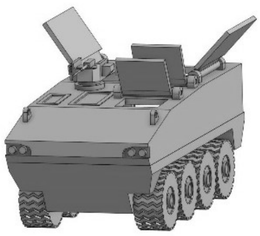
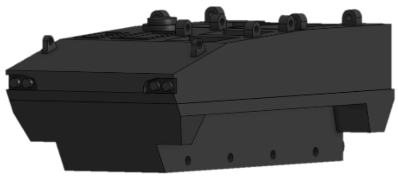
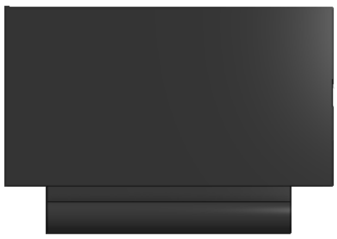
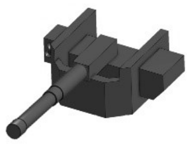
			
3D Assembly	Vehicle housing prepared for 3D printing (1x)	Hatch driver and commander ready for 3D printing (2x)	
			
Rear hatch (1x)	Rear exhaust hatch (left and right) prepared for 3D printing (2x)	Turret prepared for 3D printing (1x)	Wheel prepared for 3D printing (8x)

Fig. 2 Parts designed 3D and made with the 3D printer.

Regarding the overall dimensions of the system, it was aimed at the realization at the 1:30 scale of an armored personnel carrier, responsible for the transport of people. Considering also the limitations of the cube (length x width x maximum print height) available for printing of the 3D printer, the resulting dimensions are those presented in Table 2, taking into account that the 8 wheels are 40 mm in diameter. The height of the hatches, as well as the minimum dimension of the case on the housing network, was not chosen to be 3 mm, but the choice was made taking into account the performance of the 3D printer, the desired quality of printing, the strength of the parts and the filling characteristics in the process of printer.

Table 2. Overall dimensions of 3D printed parts.

Benchmark	Length [mm]	Width [mm]	Height [mm]
Chassis (housing)	218	100	74.33
Hatch driver and commander	25	24	3
Rear escape hatch	62	34	3
Rear hatch	54.4	46	3
Turret	47.5	29.8	10

3.2 Development of the software component of the system

The software component of the system is made integrated and preloaded in the memory of the ESP32 development peace microcontroller. Fig. 3 shows the block diagram of the software component of the system from which the main 2 components of the source code are distinguished, as follows: the Java application component (Android) whose interface is shown in Fig. 4, the component with the stored and accessed database (SaaS – software as a service) in the cloud, the hatch command and control component (Arduino-based)). The logical flow is schematically represented by the loop marked in yellow, which suggests that between all 3 components there is a logical connection, thus starting from the command and to the actuation at the level of the f final effector, the hatches. In the Body block are defined the design elements of the interface represented by the drive buttons and their positioning. In the Script block, the functions of the triggering buttons are assigned. The *communication* function *has* the lotto ensure the data exchange between the application-database cloud-command and control module, transmitting without noise the communications in the execution area. *The function of actuation and monitoring of the hatches* is provided by the actuators and the controls given by the ESP32 module that initialize and transmit angular controls in order to ensure optimal kinematics. The latter ensures that the hatches are initialed, opened and closed without overloading the actuators, while respecting the construction limits of the housing. The hatches are operated exclusively after consulting the states in the cloud database. Thus, in the Android application loop, the database is interrogated so that the commands do not overlap and successively execute the commands given by pressing the button visually presented through the respective hatches.

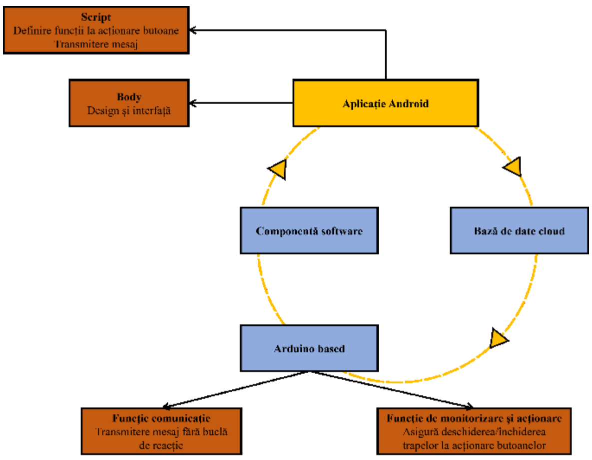


Fig. 3 Block scheme of the software component

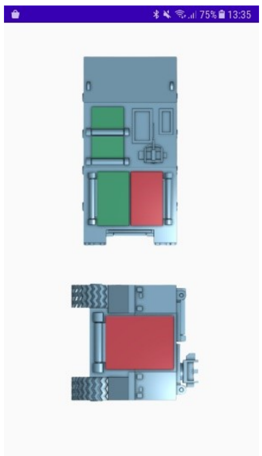


Fig. 4 Android hatch command and control app (close-green, open-red)

In Fig. 5 are presented the defined steps that the robot must follow to meet the requirements imposed by the user in the actual scenario. The steps that lead to the committing in normal parameters of the actuation of the hatches are stimulated by the triggers, which trigger the commands through which the complete execution route is made.

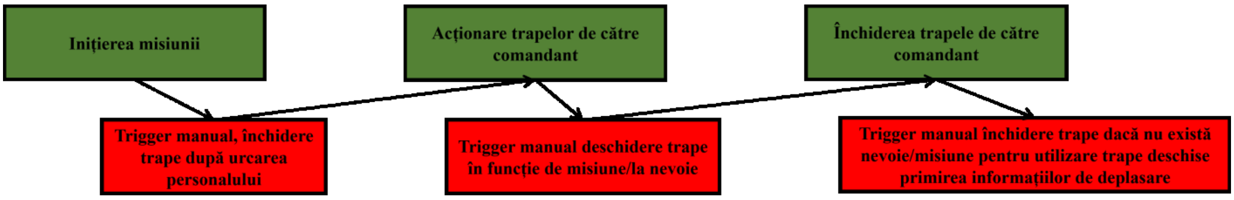


Fig. 5 Command flow and triggers (trigger elements).

4. Conclusions

According to the industrial evolution in which we find ourselves, in the future, projects based on process automation will find even greater applicability in both civilian and military fields, both of which know common elements in the production area. This work was aimed at highlighting the current possibilities of developing an action simulator and monitoring the small-scale hatches of an armored troop transport vehicle. At the same time, the use of the Android application and a cloud database highlights the ease of data distribution and the possibilities of interconnecting the components via Wi-Fi. It is necessary to mention the versatility of the 3D design application, Onshape, and the quality of 3D printing. This multidisciplinary project also involved programming components in the C++ and Java language (Android application). Regarding the project perspectives, it will be carried out to identify prototyping possibilities and other automation system for the initial testing and evaluation of the equipment on a real scale, extending the functionalities of the application already made and the methodology for creating three-dimensional models with low costs, thus improving the production process and the quality and the times in the phase of testing and evaluation.

5. Bibliography

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