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SURVEILLANCE ROBOT FOR MILITARY USE

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Abstract: *Analysis of the use of combine CAD, CAQ and CAE engineering tools in creating a mobile semiautonomous robot capable of transmitting data in real time to its user. The main objective of this paper was creating a robot capable of gathering information from different hostile environments, which can be useful for the military by offering a considerable advantage to the soldiers who are rescuing hostages in certain war areas. Using the combined capabilities of several tools, methods and software packages, a balanced concept was developed and with limited resources a mockup could be built.*

Key words: *surveillance, robots, military application, remote controlled*

1. INTRODUCTION

The military robots made their debut in the field during the beginning of The First World War, when the French Military tested the “electric torpedoes”, the idea later being abandoned due to technological issues.[1]

Fig.1. Robot with electric torpedo[1]

The robot from the above picture was used to destroy communications lines by emitting an electric wave whose sole purpose was the destruction of any communication device which integrated electric components.

Starting from this model, throughout the years countless models of military robots were created. Amongst these, worth mentioning are

1. Recon Scout Throwbot (SUA): this robot has an IR video camera, weights 540 grams, can be thrown at a distance of 36 meters and can move with a speed of 1.6km/h. [4]

2. Eyedrive (Israel): this robot weights about 2.3 kilograms, it can reach a speed of 12km/h,it has a range of 300 meters due to its wireless guidance and an autonomy of about 3 hours.[5]

3. Testudo(UK): this robot has built-in movement sensors and a thermal camera. [5]

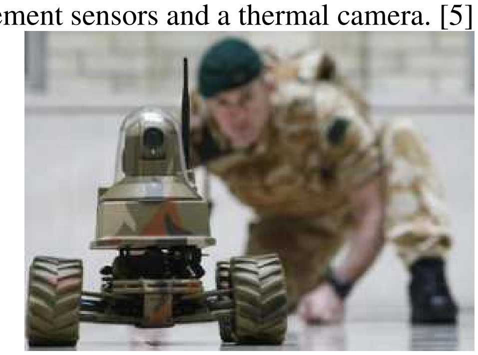

Fig.2. The Testudo Robot [5]

4. IRIS:this robot weights about 1.6 kilograms, has a speed of about 5km/h with autonomy of 1-2 hours on a 12V storage battery, and a range of 200m being controlled through GPS.[5]

Fig.3. The remote controlled IRIS robot[5]

2. THE CURRENT STATE

2.1 The problem which needs solving

The problem which we address in this paper is to develop and create the concept of surveillance mobile robot that is easily transportable, gives as much information as possible about the environment, can surpass obstacles and is made of easily replaceable parts.

The robot is to be built especially to provide assistance for the military units that are on a hostage rescue mission or are exploring an area with high risk for their lives.

The robot's purpose is to gather information and data in real time from the surrounding environment in which it operates. The information then being transmitted to the human operator.

2.2. Work methods

In order to achieve the above goals, DMAIC framework was used. DMAIC stands for Define, Measure, Analyze, Improve and Control. Following the steps of DMAIC, a concept and a mockup were developed.

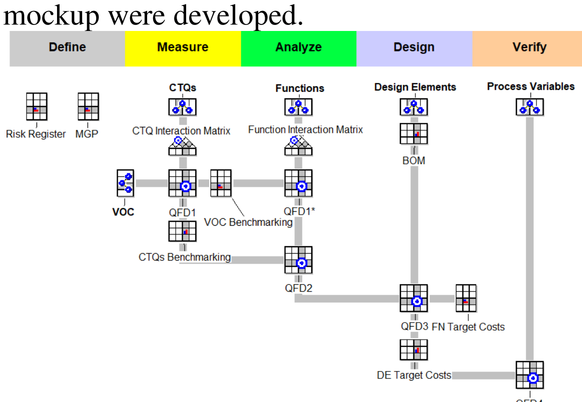

Fig.4. DMAIC framework **[6]**

In order to achieve the completion of the DMAIC framework and develop a viable concept, several competitive development methods were used. Amongst these are [7]:

- Brainstorming;
- AHP (Analytic Hierarchy Process);
- QFD (Quality Function Deployment);
- Benchmarking.

To support the implementation of the methods, the engineering aspects and the creation of the mockup, several software packages were used:

- QualicaQFD – for concept development;
- PTC Mathcad and DELMIA – for the dimensioning and creation of the 3D model;
- ArduinoCC – for the programming and control of the mockup.

2.3. Concept development

The first step was to identify the needs this robot should meet based on the current state of the art and feedback from specialists. A total of 15 requirements were identified.

The most important needs identified using the AHP method was:

1. To be able to move in hostile environment – 26.7% relevance
2. To be able to gather and transmit data and information to the operator – 13.7% relevance
3. To be able to operate at night – 9.1% relevance
4. Robust design – 8.9% relevance

The next step of the framework presumes the definition of the technical parameters and a functional assessment for mobile platform. For this the brainstorming method was used. A total of 20 critical characteristics and 13 functions were generated.

After defining the characteristics and functions, they were evaluated using the QFD method, in order to determine which are the most important.

Top three most important characteristics are:

1. Control at more than 10m – 16%
2. Autonomy greater than 30 min – 12.3%
3. Gross dimensions less than 300mm – 9%

Top three most important functions are:

1. High recording frequency – 12%
2. Have easily replaceable parts – 10%
3. Be able to move on rough terrain – 9.8%

Based on the functions, a set of ideas was generated for each function in part. For example, for the function called "be able to detect obstacles", three options were considered: ultrasonic sensors, infrared sensors or video detection. Since video detection requires high processing power, meaning a decreased autonomy. Thus, in the final concept only the first two types of sensors were used.

By combining ideas from each of the functions, several concepts were generated. Considering the 4 most likely to work concepts, they were evaluated using the PUGH method in order to identify the most appropriate one.

The final concept consists of a micro mobile platform on tracks, having a simple casing so it is easy to replace in the field, a Arduino-Nano based controller having a Bluetooth attached, one ultrasonic sensor, two infrared sensors, two arms for obstacle surpassing, two sets of tracks on wheels, one IR camera. The mobile platform is actuated by 4 micro dc motors. Two of the motors are used for generating the movement of the platform and the other two are used to actuate the arms used for obstacle surpassing.

The physical parts were correlated using a QFD with the functions of the mobile platform. Knowing the costs for each part and their correlation index, a cost/importance diagram was created.

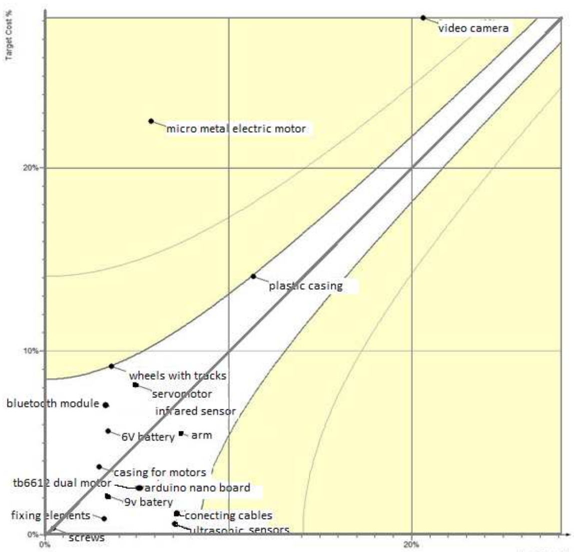

Fig.5 Cost/Importance diagram

As can be seen from the figure above the concept is well balance with respect to the overall cost and the relevance of each component.

Having a list of technical characteristics and a minimal list of components, a 3D model was created. Once the robot's components were generated in the 3D area, the search and acquisition steps followed, most of the components being bought from specialized websites such as: Robofu, Ardushop, Pololu.

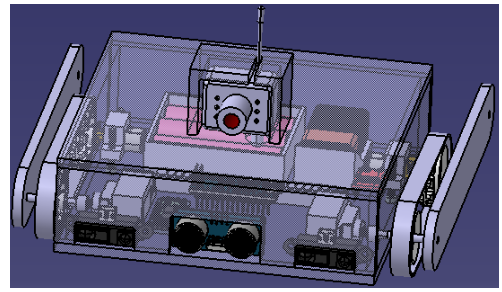

Fig.6.ThePAV.R.Mil 3D Model

3. CHARACTERISTICS OF THE MOCKUP

In order to operate the robot, four electrical motors are required to impose movement to the entire platform and the side arms. This was achieved considering the construction of the robot in order to obtain the desired results, as follows:

-outer radius of the wheels: r=35mm
-the correction coefficient: k=1.5
-the robot's acceleration: a=1.5m/s^2
-the robot's mass: m=0,88kg
-medium speed: v=1.5km/h
-angular speed: ω=11.9 rad/s
-inertia speed: Fi=1.32 N
-necessary power: P=Fi*v*k=2.97 W
-momentum: Mt=P/ω=0.24J

Because of the use of the DMAIC framework, the choice regarding the material and the design of the case is optimal.

Good results were obtained also in the recording are, where the clarity provided by the built-in camera is of 720x480 in normal light conditions, and in diminished light conditions the camera is trying to maintain a high clarity of the image due to its infrared sensors incorporated in the case. With the help of the camera the robot transmits also audio signals with the camera's microphone.

Fig.7 Camera photo test

Regarding the control and transmission part, the results are acceptable, obtaining during testing an engine speed of over 200 rot/min and a speed of the entire assembly higher than 1.2m/s powered by a 6V tension. The micro-metal HPCB engines have a high life span due to their carbon brushes.

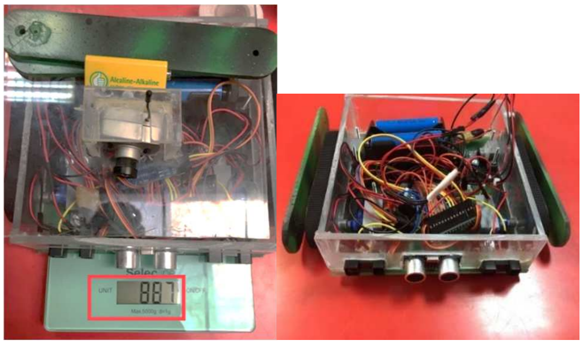

Fig.8. Mockup

The next step in creating a functioning mobile platform was the programming of the internal microcontroller (Arduino Nano) and the creation of the interface software used to control the mobile platform from a phone or a tablet.

4. CONCLUSIONS

The use of combine CAQ, CAD and CAE, tools, methods and software packages proved to have several advantages over traditional product development techniques. It focused the development process on the most relevant aspects.

The use of DMAIC framework focused the development of the concept towards a mobile platform that optimally satisfies the required functionality for a surveillance mobile platform.

The final concept is balanced with respect to characteristics, functions and cost of parts.

The mockup that was build based on the final concept has a low weight (887g), low dimensions (200x200x100 mm), high autonomy (more than 30 min.).

5. REFERENCES

[1] ***stelarul.wordpress.com/2017/02/28/ze-robots,pg 1-05.03.2019, accessed 2020.

[2] ***stelarul.wordpress.com/2017/02/28/ze-robots,pg 2-05.03.2019, accessed 2020.

[3] ***stelarul.wordpress.com/2017/02/28/ze-robots,pg 5-05.03.2019, accessed 2020.

[4] ***stelarul.wordpress.com/2017/02/28/ze-robots,pg 6-05.03.2019, accessed 2020.

[5] ***stelarul.wordpress.com/2017/02/28/ze-robots,pg 8-05.03.2019, accessed 2020

[6] *** https://www.qualica.net/cms/en/help/tools/qfd/, accessed 2020

[7] D. Popescu, et.al., Home "smartness" - helping people with special needs Live independently, Managing intellectual capital and innovation conference, 27-29 May 2015, Bari, Italy

[8] L. G. Socaciu , et.al., Using the Analytic Hierarchy Process to Prioritize and Select Phase Change Materials for Comfort Application in Buildings, DOI: https://doi.org/10.2478/mmce-2014-0003 | Published online: 12 Apr 2014

ROBOT SUPRAVEGHERE CU APLICABILITATE ÎN DOMENIUL MILITAR

Rezumat: *Analiza utilizării combinate a instrumentelor de inginerie CAD, CAQ și CAE în crearea unui robot mobil semiautonom, capabil să transmită date în timp real utilizatorului său. Obiectivul principal al acestei lucrări a fost crearea unui robot capabil să adune informații din diferite medii ostile, care poate fi util militarilor, oferind un avantaj considerabil soldaților care salvează ostaticii în anumite zone de război. Folosind capabilitățile combinate ale mai multor instrumente, metode și pachete software, a fost dezvoltat un concept echilibrat și, cu resurse limitate, s-ar putea construi o macheta..*

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