SASYR Symposium of Applied Science for Young Researchers

1st Symposium of Applied Science for Young Researchers

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Welcome

SASYR, the first Symposium of Applied Science for Young Researchers, welcomes works from young researchers (master students) covering any aspect of all the scientific areas of the three research centres ADiT-lab (IPVC, Instituto Politécnico de Viana do Castelo), 2Ai (IPCA, Instituto Politécnico do Cávado e do Ave) and CeDRI (IPB, Instituto Politécnico de Bragança).

The main objective of SASYR is to provide a friendly and relaxed environment for young researchers to present their work, to discuss recent results and to develop new ideas.

In this way, it will provide an opportunity to the ADiT-lab, 2Ai and CeDRI research communities to gather synergies and indicate possible paths for future joint work.

We invite you to join SASYR on 7 July and to share your research!

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Inclusive Mobility Solution for Visually Impaired People using Google Cloud Vision

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Abstract. Mobility in cities is of particular and growing importance nowadays due to the demographic increase and the existence of people with reduced mobility, as is the case of visually impaired people. Of the various situations where mobility represents a challenge, obtaining the notion of positioning, at times when the person loses track of where he is and becomes disoriented, can be extremely useful and a way to contribute to greater autonomy for this segment of people. This paper proposes a visual positioning system using the Google Cloud Vision API. The architecture includes a mobile application that captures an image via the mobile phone and sends it to a backend server that makes use of Google Cloud Vision to recognize the image, which may consist of text, logos or landmarks. A route in Braga was chosen to test the implemented solution. The obtained results prove the adequacy of using this solution to be adapted in a real scenario.

Keywords: Visually Impaired People · Mobility · Inclusive Mobility · Outdoor Positioning · Image Recognition.

1 Introduction

The World Health Organization (WHO), in its report on "Visual Impairment 2010", estimated the total number of visually impaired people to be around 285 million in 2010. In addition to that, it also estimated that there were 39 million blind people and 246 million people with low vision [7]. In Portugal, the 2001 reports had values in the order of 160 thousand visually impaired individuals [2] while the 2011 reports point to 900 thousand visually impaired individuals, 28 thousand of whom are blind [1]. This increase in the number of visually impaired individuals is due to the fact that in 2011, for the first time ever, not only data concerning incapability diagnostics was taken into account but also data refering to people with other types of visual deficits, such as low vision. Due to this fact, it is not possible to evaluate the evolution of the number of people with some kind of visual impairment comparatively with the year 2001. On another hand, the United Nations agenda for 2030 [5] defines 17 Sustainable Development Goals (SGDs) where the aspect of inclusive mobility is highlighted so that people with reduced mobility, where visually impaired people (VIP) are included, can have access to solutions that help them to get to relevant places they need. One of the main challenges for VIP in navigation in a city includes the difficulty of moving from a source to a given destination in an autonomous way, being able to position themselves when they lose their orientation, or even detecting obstacles in their path, such as cars and holes that hinder their circulation [6]. The Global Positioning System (GPS), although useful in some scenarios, has some limitations: 1) low signal accuracy (may present errors in the order of 1 to 10 meters of accuracy [3]), 2) fluctuations due

to atmospheric conditions and 3) delay in the response by the satellites, resulting in the slowness of the response in real time [4].

This paper presents a solution based on visual positioning to assist in the positioning of VIP in a city, using the Google Cloud Vision API. The solution includes a mobile application, which is used to capture the image of the surrounding environment and inform the VIP of nearby places through which he is passing and which are useful him to position himself and regain his orientation.

2 System Overview

This section presents the architecture of the system and its components, as well as the prototype developed for the mobile application to be tested in a real environment.

Figure 1 shows the system architecture where two main components can be identified: the mobile application and the image recognition API, which in this case is Google Cloud Vision.

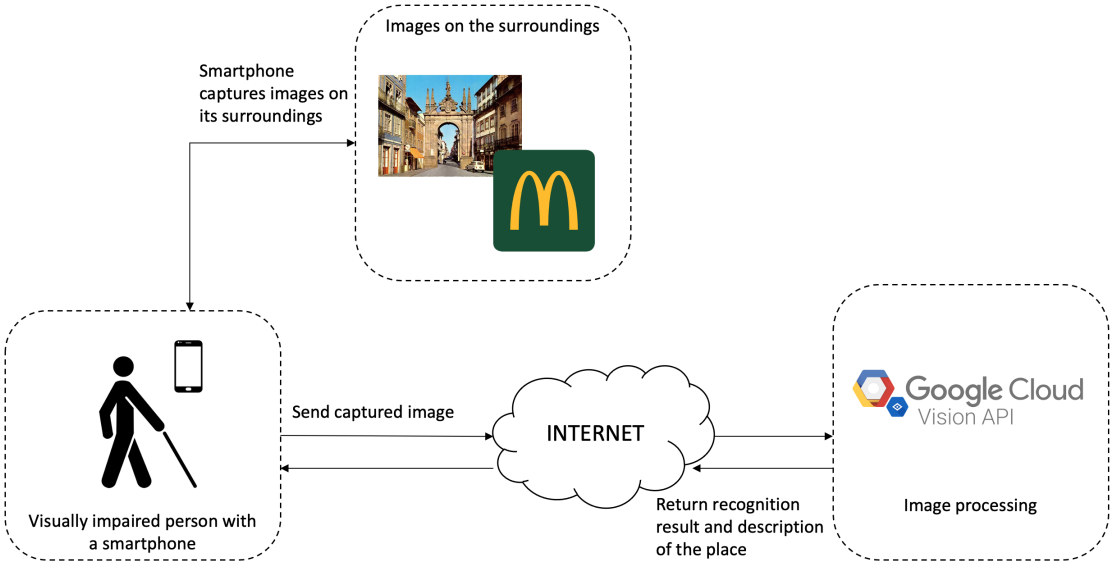

Fig. 1: Architecture of the system with two main components: the mobile application and the Google Cloud Vision API for image recognition

The system works as follows: the user, using the mobile application, should point the camera at a given location that surrounds him and, automatically, a photo is taken and sent through the application to the image recognition API of the Google Cloud Vision. The result of the image recognition process is presented to the user in audio format, using TalkBack will allow the person to identify the location to which he is facing, which represents very relevant information for a VIP to be able to locate and return guidance if he has lost it.

2.1 Mobile App Prototype

Figure 2 shows the prototype of the mobile application that was developed taking into account the maximum ease of use. When the application is opened, the camera view is automatically presented, and the capture of images is done every 7 seconds, with TalkBack or VoiceOver enabled, this information is read to the user automatically. The user can, in this way, walk down a street with his mobile phone, and receive information about the places he is passing through, provided that they consist of text, logo or landmarks.

Fig. 2: Prototype images. The application captures an image and sends the result to the user. From left to right: landmark, logo and text.

3 Evaluation

The solution was tested in a central location in the city of Braga, to assess the processing time and accuracy of the text, logo and landmarks recognition process. The route shown in Figure 3 was performed five times using the following order: (5) - (9) - (6) - (7) - (10) - (11) - (8).

Table 1 represents the accuracy and processing time of the text recognition of the locations (2) and (4), the logo recognition (1) from two different locations, one closer (5) and one with some distance (9) and the landmark recognition (3) from three different locations (7) (10) (11).

Table 1: Table captions should be placed above the tables.

	(6)	(8)	(5)	(9)	(7)	(10)	(11)
Avg. accuracy	1	1	0,98	0,97	0,49	0,64	0,48
Avg. proc.time (ms)	1694,4	1852,2	1687,4	1605	2196,8	1796,6	2278,6

In all the 5 times the route was made, the logo was recognized with a 97% accuracy from far away and 98% accuracy from up close. Both texts were recognized with

Fig. 3: Map scenario of the field tests showing the places to be recognized (1 to 4) and the places where the recognition was made (5 to 11)

100% accuracy. Lastly, landmark recognition had an accuracy smaller than 50% in two scenarios, when up close to the landmark and when there was a fountain blocking the vision to the landmark, reducing accuracy. From location 10, a better accuracy was obtained due to the fact that there were no obstacles.

4 Conclusion

In this paper, a mobile app was proposed, implemented and tested with the end purpose to help visually impaired people to move around cities and obtain information about their current location and thus solving situations where they lose orientation. Field tests were carried out in the city of Braga.

For this purpose, a route was designed that included the recognition of two texts, one landmark and one logo. The accuracy of the text recognition was 100% with an average processing time of 1.8 seconds. The recognition of logos had an accuracy of 98%, and the greater distance to the logo was not significant. The processing average in this case was 1.6 seconds. Finally, recognition of the landmark always gave the correct location as a return, although the accuracy varied when it was too close and when there were obstacles ahead. The average processing time, in this case, was 2.2 seconds. The decrease in average processing times in tests carried out in a real scenario is highlighted, which may eventually be justified by the use of mobile data.

The use of this API proved to be adequate for the defined problem research, and it can be a viable solution for incorporation in a mobile application with the objective of helping visually impaired people to have a greater orientation when moving in cities.

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Detection of Atypical Patterns - A Machine Learning Approach

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Abstract. Throughout the present work, some methods were tested in order to perform the rejection of patterns not contained in the training group (atypical), i.e. patterns for which the model was not trained to recognize. Supervised Classification algorithms are only trained to recognize and classify certain patterns, those contained in the training group. Therefore, these will incorrectly classify unknown patterns by default, causing unwanted results.
In previous work, the main approach for the development of models capable of recognizing these patterns was the use of a Variational Autoencoder (VAE). In order to validate the effectiveness of the VAE, a Convolutional Neural Network (CNN) was also tested in the execution of the referred task. Since the VAE as presented to be more effective in the detection/rejection of atypical patterns, several conventional Machine Learning techniques, using features extracted from the CNN were also tested.
This work aims to propose a much faster solution by only using conventional feature extraction methods, such as Haralick features, Local Binary Patterns (LBP), and Histogram of Oriented Gradients (HOG). Some interesting results were obtained, demonstrating that using traditional feature extraction methods is a viable option for achieving the goal of this work.

Keywords: Machine Learning · Atypical Patterns · Feature Extraction.

1 Introduction

Artificial Intelligence (AI) has been one of the areas in Computer Science that have gained more importance in recent years [6]. This increase in significance is due to its ability to perform tasks that historically only humans could perform and, in most cases, can execute them even faster and more efficiently than the human being himself.

Within the area of AI, Neural Networks (NNs), trough a vast set of algorithms that work in analogy to human neurons, allow the recognition of the most varied data patterns. Due to its recognition capacity, the NNs, specifically the Supervised Classification Neural Networks (SCNNs), constituted a fundamental tool in the development of previous work [8] because they allow the grouping and classification of images using Deep Learning (DL). To be able to carry out the described task, SCNNs are subjected to a training process through which they learn to recognize specific patterns. These patterns are defined as belonging to a particular category/class. However, as SCNNs are only trained to recognize and classify specific patterns, those contained in the training dataset. When they find an atypical pattern, compared to the training dataset (i.e.), a pattern that does not belong to any of the classes known by them, by default, they will classify the unknown pattern as belonging to one of the dataset classes, thus causing undesired results.

In previous work [8], three distinct models of AutoEncoders (AEs) (algorithms specialized in the reconstruction of the information through its learning) were used: Simple AutoEncoder (SAE), Convolutional AutoEncoder (CAE), and Variational AutoEncoder (VAE). After performing several tests on the mentioned models of AEs, it was determined which one performs better the task of detecting/rejecting atypical patterns to the training dataset. Subsequently, a Convolutional Neural Network (CNN) for classification was also developed, in order to compare its performance with the performance of the best AE model, thus determining the model that best performs the detection/rejection of atypical patterns. Additionally, with the CNN model previously trained, the training features from this model were extracted to test the ML algorithms' ability to detect atypical patterns. The goal of this work is to propose a much faster solution, and compare the effectiveness of traditional feature extraction methods with a CNN.

2 Methodology

The present section describes the feature extraction methods used and the chosen ML algorithm used to perform the classification.

2.1 Feature Extraction

Gray Level Co-occurrence Matrix: The Gray Level Co-occurrence Matrix approach, also frequently called the spatial gray level dependence matrix (SGLDM) approach or haralick features, is based on studies of the statistics of pixel intensity distributions. Single-pixel statistics do not provide rich enough descriptions of textures for practical applications. Thus it is natural to consider the second-order statistics obtained by considering pairs of pixels in certain spatial relations to each other. Hence, co-occurrence matrices are used, which express the relative frequencies (or probabilities) P(i, j—d, θ) with which two pixels having relative polar coordinates (d, θ) appear with intensities i, j. The co-occurrence matrices provide raw numerical data on the texture, although these data must be condensed to relatively few numbers before they can be used to classify the texture [5].

Local Binary Patterns: The LBP method, first proposed by Ojala et al. [9], encodes the pixel-wise information in textured images. Images are probed locally by sampling grayscale values at a central point x0, 0 and p points xr, 0, ..., xr, p-1 spaced equidistantly around a circle of radius r (the choice of which acts as a surrogate for controlling the scale of description). In LBP, a "local pattern" operator describes the relationships between a pixel and its neighborhood pixels; all neighbors that have values higher than or equal to the value of the central pixel are given a value of 1, and all those lower a value of 0. The binary values associated with the neighbors are then read sequentially, clockwise, to form a binary number which may be used to characterize the local texture [7].

Histogram of Oriented Gradients: Navneet Dalal and Bill Triggs introduced HOG features in 2005 [4]. Histogram of Oriented Gradients (HOG) is a feature descriptor used in image processing, mainly for object detection. A feature descriptor is a representation of an image or an image patch that simplifies the image by extracting useful information from it [2].

2.2 Machine Learning Method

Previous work [8], shows that among several classifiers, Random Forest (RF) is the conventional ML classifier that has the best performance, in the rejection of atypical patterns.

Random Forest classifiers fall under the broad umbrella of ensemble-based learning methods. They are simple to implement, fast in operation and have proven to be highly successful in various domains. The random forest approach comprises many "simple" decision trees in the training stage and the majority vote across them in the classification stage. Among other benefits, this voting strategy can correct the undesirable property of decision trees to overfit training data [3].

3 Proposed Approach

The process of rejection/identification will consist on the determination of two threshold values. With these thresholds, it will be possible to define conditions to classify the introduced pattern, as typical or atypical.

The feature extraction methods enable the use of ML learning techniques, in order to classify images in the correct category. The output of the ML technique used (RF), is the probability given by the prediction for each class. Using these probabilities, the definition of the thresholds will be the same as the one used in previous work [8], using the CNN as a feature extraction method and applying conventional ML techniques. Ten typical patterns were used, for the calculation of both thresholds.

For the calculation of Threshold 1, the mean and the standard deviation of the highest probabilities were calculated (the highest probability in the set of all classes). Threshold 1 allows to know the threshold value that establishes one of two classification boundaries of a typical-atypical pattern.

For the calculation of Threshold 2, the mean and the standard deviation of the differences between the two highest probabilities were calculated. Threshold 2 allows to know the threshold value that establishes the boundary of classification of a pattern as typical-atypical.

Once defined the Thresholds, it has been determined that an atypical pattern will be identified when the maximum activation value (highest probability) is below Threshold 1 or, the Euclidean difference between the two highest probabilities is less than the Threshold 2. It has also been determined that a typical pattern will be identified when the maximum activation value is greater than Threshold 1 and, the euclidean difference between the two highest activations is greater than Threshold 2.

4 Tests and Results

This section presents the tests carried out, using the method described in the previous section, in order to determine the most effective feature extraction method and method as well, in the detection of atypical patterns. The training process was done, using the well known MNIST dataset [1]).

A test dataset was built, that consisted of 30 typical and 30 atypical patterns to evaluate the performances (all of them are numeric digits that belong to the MNIST dataset [1]).

4.1 Results

All the feature extraction methods have performed differently in the classification process. In order to compare conventional feature extraction methods with methods based on DL, the Table 1 show the values obtained for the performance measures of all methods.

Table 1: Performance Comparison

Metric / Variant	Accuracy	Sensitivity	Specificity
AE	0.8333	0.9600	0.8286
CNN (feature extractor)	0.7500	1.0000	0.6667
Haralick	0.6500	0.7647	0.6047
LBP	0.7166	1.0000	0.6383
HOG	0.5167	1.0000	0.5085

After the analysis of this table, it is possible to verify that the percentage of success when almost all models claim that a certain pattern is typical (Sensitivity) is higher than the overall percentage. However, when the models claim that a certain pattern is atypical (Specificity), the hit rate is less than the overall percentage (Accuracy).
It can also be seen that in the detection of atypical patterns, the CNN, the LBP and HOG, had correctly identified the totality of patterns analyzed. Although we have a low specificity rate by introducing this detection capability to the RF using LBP as feature extractor. It can also be seen that although the HOG as a feature extractor achieved the maximum sensitivity rate, it is also the worst at specificity. Overall, the stronger model that would be the recommended one to perform this detection is the VAE. This model just miss classifies one atypical pattern, and we also just loose 6 typical patterns. Although the simpler methods (without using DL techniques), achieved a lower accuracy rate, these methods proved to be much faster than methods based on DL. This solution can be integrated in systems that need to have a faster training process, due to the volatility of data in some circumstances.

5 Conclusion

This work has presented some feature extraction methods to detect/reject atypical patterns in ML classification problems. This work has consisted in the development of several strategies, using only conventional feature extraction methods, instead of using only DL methods or the CNN as feature extractor to do it. This work aims to perform the classification process in a much faster way, than DL methods. It was proved in this work, that conventional feature extraction methods are also able to detect these

patterns, reject all the atypical ones and also keep a significant percentage of typical ones.

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Data Acquisition and Conditioning System for a Wearable-based Integrated Biostimulation

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Abstract. Wearable technology has a wide range of applications, e.g. gaming and medicine. In medical wearable systems, the muscular data is collected by biopotential measurements called electromyography, which recording the electrical activity of the skeletal muscles. This abstract describes the signal acquisition and conditioning system for a wearable-based muscle electrostimulation that uses dry electrodes of titanium thin films. The proposed system employs Bluetooth Low Energy to transmit the acquired signals to an mobile application in a smartphone for later visualization and analysis by the clinical team.

Keywords: Wearable, Dry electrodes, Electromyography, Functional Electrical Stimulation, Bluetooth Low Energy.

1 Introduction

Wearable technology has a wide range of application fields such as gaming, medical analysis and human machine interface [1, 2]. The benefits of the wearable technology include compactness, practicality and continuous monitoring. Since the wearable is not dependent of other devices, it can be used standalone and the experiments can be performed remotely, e.g., the medical analysis can be done at home by the patients [4].

In a wearable system, the muscle data is collected by biopotential measurements, namely electromyography (EMG) that is an electrodiagnostic medicine technique for evaluating and recording the electrical activity produced by skeletal muscles [6]. The surface electromyography (sEMG) is a non-invasive EMG technology, which has been used in wearable systems by using electrodes placed on the body surface enabling the study of the muscle function in a natural setup, as well as the study of the density of nerve-muscle interactions [2].

In order to obtain a high accuracy, reliability and reproducibility in the sEMG measurements, several factors need to be considered, namely avoid the noisy electrical environments, minimize artefacts caused by changes of electrode-skin interface or by cable movements, consider the biological conditions, and the exact positioning of the electrodes according to the international standards and/or conventions [7].

The electrodes in sEMG are responsible for the quality of the received signals, which can be classified into disposable (wet) or reusable (dry) [5]. The wet electrodes have a long setup time being preferred to sense the motion. Moreover this type of electrode employs an electrolytic conductive gel in order to reduce the contact impedance between the electrode and the skin [7]. However, they are generally not indicated for long-term applications, because the quality of the signal decays due to the gel dehydrates over time, being generally considered for single usage. Furthermore, the gel can provoke the

skin irritation and allergic reactions [3]. These limitations show that it is not a good option to adopt the wet electrodes in wearable applications, and it is necessary to use electrodes that are reusable, flexible, and washable, which can be reached by using dry electrodes [5].

The dry electrodes are an option available in the market preferred for wearable applications, recommended for long-term recording via the direct skin contact without gel [2]. They generally also produce little skin reaction. Nevertheless, rigid dry electrodes are uncomfortable to wear and have a high skin-electrode impedance. The flexible dry electrode technology is an alternative could mitigate these problems due to better skin contact and flexibility [3].

Several several solutions for wearable technology are available, e.g., a wireless wearable comprising 8 channels, noise cancelling, data transmission via WiFi and ADC 12 bits resolution [2]. This solution also uses a bandwidth of 20 to 500 Hz based on wet electrodes.

Having in mind to develop a wearable system for medical treatment on the vastus medialis muscle, this abstract describes an EMG data acquisition and conditioning system, as part of a wearable eletrostimulation system that uses dry electrodes. The proposed prototype, on the opposite of [2], allows to stimulate each 10 ms according to the stimulation protocol, preset by a medical prescription, and record the data from the muscle employing a similar sampling frequency of 1 kHz. After each 1 s, it transmits all recorded data, by using the Bluetooth Low Energy (BLE), to a smartphone application that will show the results of the therapy session (muscular signals) to the patient and clinic team. Moreover the proposed system is based on dry electrodes that avoid the use of the gel and the waste generated when applying the disposable electrode.

The rest of the abstract is organized as follows: Section 2 describes the proposed wearable system architecture and Section 3 presents the preliminary achieved results of the developed system.

2 System Structure

The proposed wearable system for treatment of injuries on the vastus medialis muscle contains the functions of acquisition and conditioning of the EMG signal (amplification, filtering and conversion analogue to digital) to support the monitoring, control the electrostimulation and the subsequent transmission of acquired data to the mobile application via Bluetooth Low Energy (BLE) to the mobile application running in the smartphone, as illustrated in Fig. 1.

In the system, several steps are considered to close the feedback loop EMG, the signal acquisition and conditioning, and the Functional Electrical Stimulation (FES) control. Initially, the EMG signal is acquired through dry electrodes and then properly conditioned to extract, amplify and filter small biopotential signals in the presence of noisy conditions, created by motion, remote electrode placement and connection between electrode and the wires.

The analogue-to-digital converter (ADC) allows the conversion of the acquired and conditioned signal to digital format, being the output signal used as input of a low power microcontroller. The microcontroller will host the biostimulation control, which

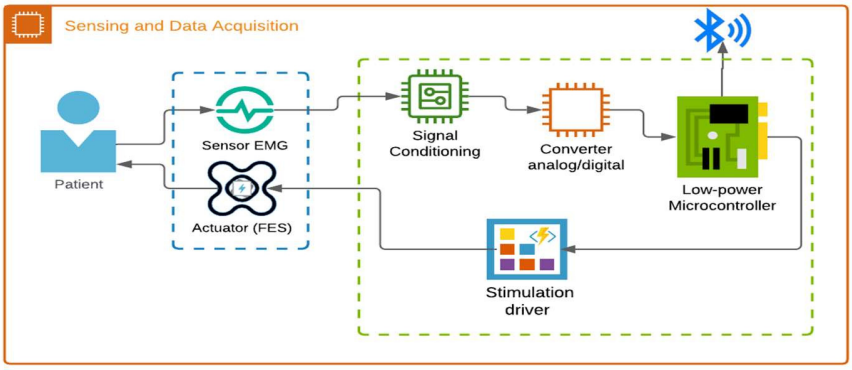

Fig. 1: System architecture focusing the acquisition, signal conditioning and electrostimulation system.

is responsible for controlling the electrostimulation according to the acquired EMG signal and a pre-defined therapy model. This electrostimulation control continuously determines the signals to be sent to the FES, in terms of pulse amplitude, duration, and frequency, the ratio between stimulation/resting periods, as well as shape of the pulse train.

The stimulation driver is responsible to properly prepare the applied electrical stimuli in the dry FES actuator to induce the skeletal muscle contraction, enabling the restoration of functional movements and treating the injuries on the patient's muscle.

The proposed system use wireless technology in order to transmit the data acquired from the EMG embedded in the wearable to the external device, e.g., a smartphone, that later send them to the cloud to be analysed by the clinical team. Several different wireless communication protocols can be employed, namely Wi-Fi, BLE, ZigBee and Z-Wave, but the selected protocol was BLE since it is a low cost, low consumption and simple communication protocol, that is widely used in similar applications.

3 Preliminary Results

As presented in Fig. 2, for the initial tests aiming to evaluate the different kinds of dry electrodes, in terms of diameter and material, the commercial *Bitalino core* platform was used. This board was projected to medical applications, is based on the Arduino platform and has an ADC with 10 bits of resolution. Furthermore, the EMG sensor has a bandwidth of 25 to 480 Hz and range ± 1.64 mV responsible by doing the signal conditioning, where the electrodes are plugged being possible to collect the muscular signal. This approach sends the data via Bluetooth to a desktop where a MATLAB API, developed by the Bitalino manufacturer, was used to collect and visualize the EMG signal near real time. Moreover, the application does a signal processing which removes the value and the signal trend through the Matlab's *detrend* function. The code also filters the 50 Hz noise component of the acquired signal and computes the signal energy over time.

As illustrated in Fig. 3, with the initial results, it is possible to conclude that the EMG signal has a high magnitude noise due to the low quality of the kit connectors.

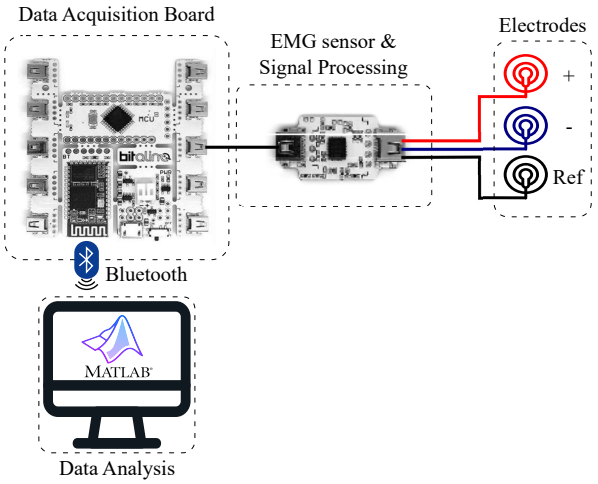

Fig. 2: Acquisition and signal conditioning system for the preliminary tests.

This unstable connection introduces high instability in the measurements during the muscle movement. This can be solved by considering more stable and robust electrical connectors.

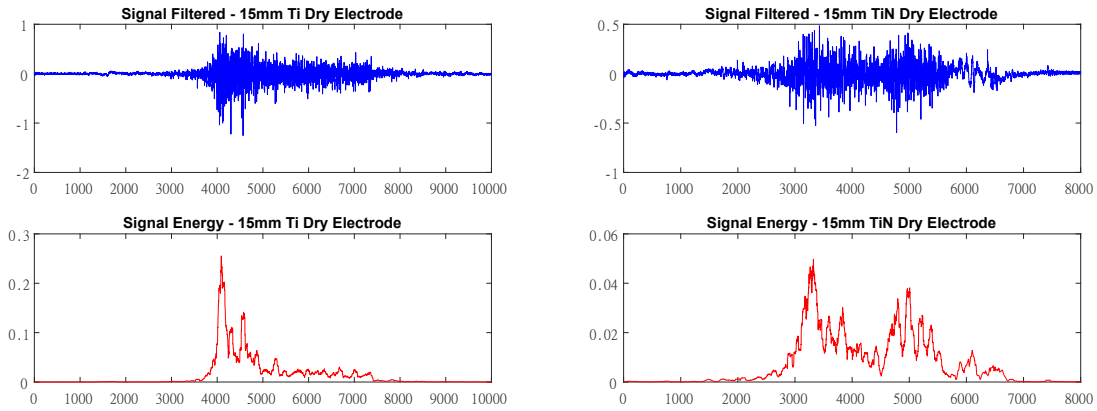

Fig. 3: EMG signals acquired from the dry electrodes using the Bitalino board.

These initial tests were also developed to evaluate the dry electrodes performance, so different types of electrodes were considered. Namely, the electrodes under testing were constructed using two different materials (titanium and titanium-nitride), and three distinct diameters (7, 15 and 34 mm). Shortly, it is possible to conclude from the preliminary tests that the medium electrode diameter is the best choice since it does not lost the contact with the skin, what happened using the smallest electrode, and it is compact when compared to the biggest diameter what is important in a wearable system. The analysis of the dependence from the type of material will be only possible after improving the electrodes' connection.

Acknowledgment

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Robotized Automation Systems For Industry Supported By Integrated Quality And Environment System Management Solutions

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Abstract. In the current economic environment, the path to success for organizations is more demanding than ever and managers are faced with increasingly complex problems. With the main objective of creating competitive advantages and achieving sustainable development, organizations implement different Management Systems, including Quality Management Systems (ISO 9001) and Environmental Management Systems (ISO 14001). The emergence of the High-Level Structure across all ISO standard, in a way, facilitates the arising of integrated systems. The "PDCA Cycle" also allows an organization to ensure that its processes are adequately resourced and managed and that opportunities for improvement are determined and implemented. This article is the result of a project developed in a company, which presents a wide range of solutions for robotized automation systems. Its main objective is the definition and implementation of ISO 9001:2015 and ISO 14001:2015, in order to reach new markets and in this case other type of clients. The organization was analysed, and a Quality Management System was structured based on its three main principles: Process Approach, PDCA Cycle and Risk-based Thinking. The Process Approach was also applied to the Environmental Management System. In the latter, significant environmental aspects were identified, as well as applicable legislation and other requirements, its Environmental Policy was also formulated. In short, the implemented Integrated Management System will allow a logical and systematic management approach that will translate into strategic management and operational decisions, which will allow a greater projection of the company in the global market.

Keywords: Quality Management Systems, Management Systems,Management Systems, Robotized Automation Systems.

1 Introduction

Due to market development and the need to respond not only to customer satisfaction, but to a comprehensive set of Stakeholders, many companies have chosen to implement different standardized management systems [1]. The sustained success of the business is achieved by creating value for the relevant Stakeholders and Society in general, through efficient management and the full understanding of its various requirements and associated risks, considering the internal and external context [2]. The impact generated by quality and environmental systems is evident. According to the definition of the ISO 9001:2015 standard, quality is understood as "the degree of satisfaction of requirements given by a set of intrinsic characteristics of an object". It is then up to each organization, to meet the needs and expectations of its Stakeholders, to equip itself with the necessary means and resources so that its products and/or services meet them. Thus, we can say that Quality contributes in a large part to the success of an organization, because if its culture is based on its principles (Fig.1), issues such as increased efficiency,

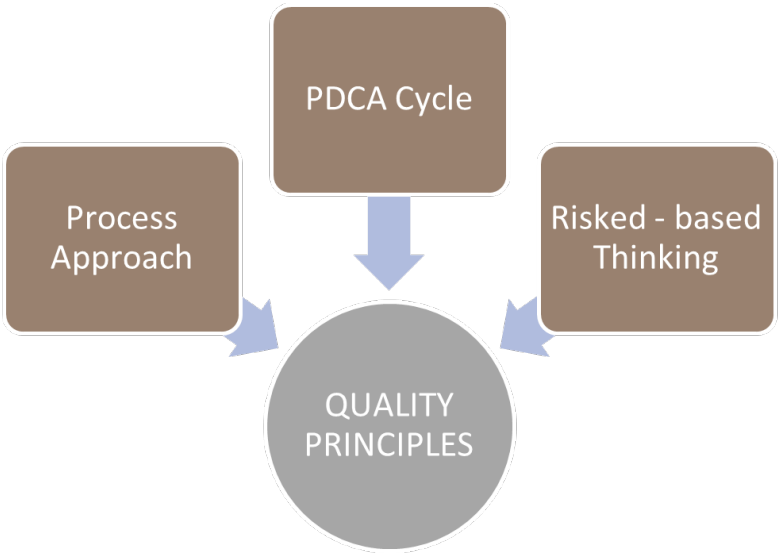

Fig. 1: Quality Principles (Source: Elaborated by the author)

focus on continuous improvement of its processes, will certainly make their products and/or services stand out positively among its competitors [3].

On the other hand, ISO 14001 is a certification that ensures that a company can consistently control their significant impacts on the environment and continuously improve operations and business [4]. If in a first phase its implementation was mainly motivated by the improvement of production efficiency, or by environmental issues related to legal compliance, currently this adoption is made through the increasing institutional loyalty it provides. It offers the ideal scenario for the effective development of an Environmental Management System [5]. The fact that there is an Annex SL (High Level Structure) across all ISO standards, in a way facilitates the emergence of integrated systems. In terms of practical application, this process was a great "leap" in terms of both simplifying the system itself and the continuous maintenance it requires. Another aspect that also contributes to the effectiveness of the integration of the various management systems is the "PDCA Cycle" (Fig. 2). According to the definition of the ISO 9001:2015 standard, it "allows an organization to ensure that its processes are adequately resourced and managed, and that opportunities for improvement are determined and implemented".

1.1 Objectives

The main objective is to define and implement an integrated quality and environmental management system according normative references ISO 9001:2015 and ISO 14001:2015, which will form part of the company's management strategy. To achieve it, the following specific objectives are proposed:
– Characterize the organization's process maps and their monitoring;
– Identify all Stakeholders and survey their needs and expectations;
– Determine quality and environment related risks and opportunities;

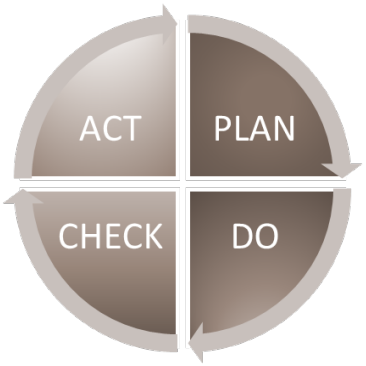

Fig. 2: PDCA Cycle (Source: Adapted by the author)

– Define the different processes inherent to the company and their interactions;
– Establish goals and respective actions (Quality and Environment);
– Identify the environmental aspects and their impacts and determine the significant ones;
– List all associated legal obligations, especially with regard to environmental issues and determine their compliance;
– Create procedures/methodologies for QMS and EMS operationalization;
– Perform internal and external audits.

1.2 Methodology

The focus of the Project on which the article was based, was to support the organization to achieve its goal and for this, the "Case Study" method was taken into consideration. According to Meirinhos it "is an empirical investigation that investigates a contemporary phenomenon within its real-life context, especially when the boundaries between the phenomenon and the context are not clearly defined". Therefore, Case Studies are based on the development of knowledge through a scientific method that considers the facts individually (cases) [6], whose purpose of the research is the intensive study of one or a few cases. However, despite some differentiation, sometimes conceptual, depending on the epistemological framework of the authors, their methodology is formed by a set of fundamental characteristics such as: Nature of research, Holistic character, Context and its relation to the study, Possibility of making generalizations, Importance of a prior theory and Constant interpretative character [7].

1.3 Implementation Details

Using the methodology described above, the work will be divided into the following stages:
– **First Stage**: Intervention proposal.
– **Second Stage**: Company approach.
– **Third Stage**: Diagnosis of the company in relation to the requirements of the quality

and environment management system.
– **Fourth Stage**: Action plan.
– **Fifth Stage**: Definition and implementation of integrated quality and environment management system.
– **Sixth Stage**: Audits.
– **Seventh Stage**: Certification.

2 Results and Conclusions

As a result of the diagnosis made and the action plan established, the Quality Management System was structured based on its three main principles. The process approach was also applied to the Environmental Management System. With regard to the latter, the significant environmental aspects were identified, as well as the applicable legislation and other requirements, and its Environmental Policy was also formulated. Notwithstanding the above, the organization has also determined the relevant external and internal issues that may affect its ability to achieve the desired results, as well as the needs and expectations of Stakeholders. The main objectives of quality and environmental were: Reduce Nonconformities, Promote waste sorting, Environmental sustainable suppliers, Improve costumer satisfaction and Increased turnover.

At this moment the company has already obtained certification in the two management systems mentioned, filling the existing gap in the organisation re- garding this subject, having always as an objective the continuous improvement possible with its maintenance over time. The Certification of the two integrated systems will bring clear benefits in the short and long term, managing to reach markets that without it would be unviable. These markets are fundamental to project the company into the future and allow its visibility and growth. For the future work it is foreseen the integration of the occupational health and safety management systems (ISO 45001:2018).

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Real-time Monitoring and Controlling of Internal Parameters for Smart Buildings

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Abstract. Health risks caused by air contamination have become increasingly worrying, especially when it comes to indoor air quality (IAQ), where there is a lot of concentration of gases such as carbon monoxide (CO), carbon dioxide (CO_2) and volatile organic compounds (VOC), and it is where people spend the most part of the day. With that in mind, this article presents a research that is being done in the area of intelligent building automation, which aims to develop an IAQ monitoring and control system using internet of things (IoT) technology. For this, some sensor modules will be connected, such as the BME680 and the AMBIMATE MS4, to the ESP32 microcontroller that will send the collected information to the monitoring and data storage platforms using the Message Queuing Telemetry Transport (MQTT) data exchange protocol through of the Node-RED online tool. With this device, in addition to being able to monitor the internal parameters of the environment where it is installed, it will be possible to detect any adversity that may arise in the place and providing autonomously an output signal that can trigger an actuator capable of stabilizing the system, that is, without the need for any human action.

Keywords: internet of things · IAQ (indoor air quality) · environmental monitoring.

1 Introduction

The increase of pollution in urban areas has become increasingly worrying. According to the World Health Organization (WHO) it is estimated that more than 90% of the world's population breathes polluted air [12]. People spend most of the time in closed environments, whether at home, at school or at work, where they are often exposed to substances that are harmful to health such as CO, CO_2 and VOC [9], so the control of IAQ is very important.

This article presents a research that is being carried out with the aim of developing a device that is able to monitor and control air quality and safety parameters inside of smart buildings, as well as temperature, humidity, pressure, CO_2, VOC, among others, in order to promote a better quality of life for people who suffer from health problems caused by poor air quality.

2 Related Works

IoT technology and building automation has been important themes in academic research in recent years, in this section, the studies being carried out in the areas of IoT

and smart buildings will be presented and evaluating what has already been done, in order to show the value of this work in relation to this area of research.

In table 1 query results from Google Scholar, IEEE Xplore™ and ScienceDirect using kewords like IoT, Smart Buildings and Monitoring Systems are presented. Only results from 2017 onwards were considered.

Table 1: Results of systematic literature review.

Key words	Google Scholar	IEEE Xplore™	ScienceDirect
IoT	218 000	37 162	20 373
Smart Buildings	409 000	8 969	47 377
Monitoring Systems	959 000	56 128	691 069
IoT and Smart Buildings	16 800	595	6 852
IoT and Monitoring Systems	43 000	6 887	13 097
Smart Buildings and Monitoring Systems	17 600	483	23 943
IoT and Smart Buildings and Monitoring Systems	17 000	187	5 445

The data presented in the table 1 show that there is a large number of research being developed on the keywords, even when looking only for studies that involve the whole set (IoT and Smart Buildings and Monitoring Systems). However, most of this material only develops the monitoring of parameters present in buildings and only a small portion of the studies present an application of control and action on the data collected by the sensors responsible for monitoring. In [10] is presented an Internet of Things (IoT) based smart controlling system to save electricity consumption of air conditioners, including smart meter, smart gateway, and cloud computing modules that is able to realase the monitoring in the real-time. In [6] several arguments are presented for the introduction of IoT systems in order to assess the environmental quality of buildings. The architecture proposed by the authors constitutes a set of integrated sensors, capable of measuring ambient temperature, humidity, atmospheric pressure and detecting volatile organic compounds. This group of sensors was connected to a microcontroller, which periodically sends the sensor data to a server, making it possible to access the collected data from a web portal. The tests performed were in a laboratory environment, similarly to what is being done in this proposed work, however, in the evaluated article, performances in the environment were not demonstrated. As the ability to act in the environment is an essential component of a flexible and robust IoT architecture, in the proposed work, it is expected to present at the end of the work a control system capable of sending output signals to actuators as needed by the system.

3 Research proposal

This work aims to develop a module capable of monitoring IAQ and fire, through information stored in a database, apply machine learning techniques in the system so that it can recognize possible adversities present in the parameters that are being measured and in response, emit an output signal that can be routed to an actuator.

The research material developed so far is presented below, as well as the proposal of what is still intended to be developed.

3.1 Work development

Figure 1 presents an overview of the system comprising the IoT module, sensors, actuators, communication protocol, cloud storage system and data analysis system. The sensors used for IAQ monitoring will be the BME680, a 4-in-1 digital sensor measuring gas, humidity, pressure and temperature [2], and the AMBIMATE MS4 module, used to detect characteristics of indoor environments, uses a set of sensors capable of measuring temperature, humidity, ambient light, motion, VOC and CO_2 [11]. For fire monitoring, the MQ5 gas sensor for smoke detection [13] and an IR sensor that uses a highly sensitive infrared receiver to detect the flame spectrum will be used.

The parameters measured by the sensors are read by ESP32, a high-performance, low-energy microcontroller that features a low-power microprocessor, 52 kB RAM and built-in flash memory, as well as support for WiFi and Bluetooth networking [4]. The architecture of this device allows it to be programmed independently, without the need for other microcontroller boards like Arduino [1], for example.

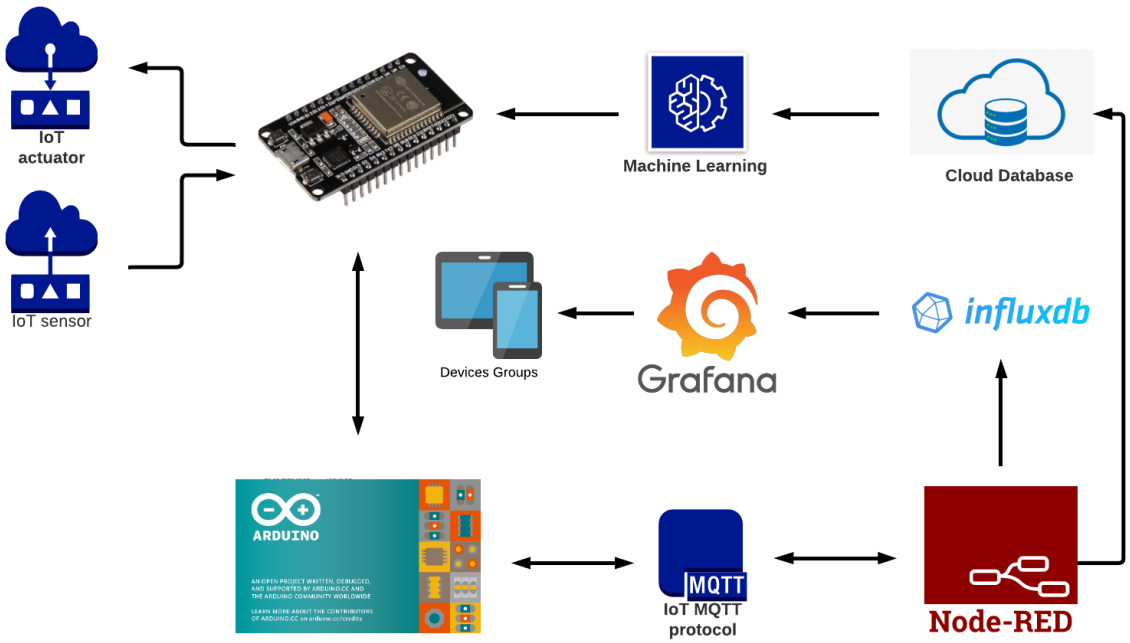

Fig. 1: System architecture.

In figure 1 the communication protocol responsible for the exchange of information between the microcontroller and the monitoring and data storage platforms is the MQTT (Message Queuing Telemetry Transport Protocol), a standard Publisher/Subscriber messaging protocol, widely used for Machine-Machine (M2M) communications in IoT contexts, due to its easy implementation [7]. This protocol was chosen for the development of the work considering that the program used to implement the control rules, Node RED, an open source tool used to connect devices and online services [3], already

had a node referring to the MQTT , semi configured, making it the most practical choice. Information sent to Node-RED via MQTT is stored in InfluxDB, a database optimized for fast storage and availability for retrieving data from IoT sensors and real-time analytics [8].

The monitoring of the parameters being measured is done through Grafana [5], a data analysis web application used to create monitoring panels, often used in combination with time series databases, such as influxDB.

While the database does not have enough information to be used, machine learning methods will be studied in order to obtain a system capable of recognizing any adversity that may arise in the environment being monitored and providing an output signal that can trigger an actuator capable of stabilizing the system.

4 Conclusions and future work

As new technologies emerge in the areas of IoT and automation, it is possible to develop monitoring systems that are increasingly cheaper, simpler and more effective. The results of the present study show that many low-cost sensors have the potential to be used to provide a safe indoor environment. Projects like this have increasingly shown the importance of this area of research in people's quality of life.

The work presents a sensor module for monitoring IAQ and fire where the information collected will be stored in a database and later will use machine learning to implement the control part of the system.

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ECG Monitoring System for Atrial Fibrillation Detection Based on an Android Mobile Device

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Abstract. This paper proposes the implementation of a electrocardiogram (ECG) monitoring system for R peak (heartbeat) detection and Atrial Fibrillation detection. The system consists of a signal acquisition step performed by the BITalino® HeartBIT BT platform. The acquired signal is transmitted to a smartphone using Bluetooth communication. The algorithm is responsible for detecting the R peaks of the acquired ECG signal and run a machine learning model based on a Long Short - Term Memory (LSTM) neural network to perform Atrial Fibrillation detection. The implementation of such an algorithm in an Android environment can be done with tools such as MATLAB Coder® application, Android Studio® and the Java Native Interface.

Keywords: ECG Monitoring System· Atrial Fibrillation Detection· Android Device ECG Processing

1 Introduction

Cardiovascular diseases (CVDs) are one of the main causes of death around the world, thus making it imperative to continuous research for efficient diagnostic tools and methods for preventing heart-related diseases [1].One of the most used tools in the diagnosis of CVDs is the electrocardiogram (ECG) [2], which consists of the graphic representation of the electrical activity of the heart. Cardiac arrhythmias represent a type of CVD that affect the rhythm of the heart. One of the most recurrent arrhythmia is atrial fibrillation (AFIB) which, despite not having a high lethality, consists of a pathology that often needs medical monitoring, since it can increase the chances of heart attacks and strokes. Atrial fibrillation occurs when the atria contract in an irregular and out of synchronization with respect to the ventricles. This is due to multiple abnormal electrical impulses generated in the atria. These random electrical stimulus cause the atria to contract incorrectly and the blood may stop flowing into the ventricles, decreasing the efficiency and performance of the heart. With the development of wireless technologies, more and more mobile heart monitoring systems through ECG analysis are being implemented. These systems are a powerful tool for the early diagnosis of disorders such as atrial fibrillation. In addition to allowing constant monitoring of the patient's ECG signal, mobile monitoring systems assist in the diagnosis of heart disease and help to avoid human fatigue errors in the analysis of long-term signals. In general, ECG signal monitoring systems consist of four main steps as illustrated in Fig. 1. The first step concerns the acquisition of the ECG signal through a wearable device connected to the patient. This step has to be able to acquire the signal with low incidence of noise and high reliability. The acquired signal is then digitized and sent to the second stage of the

system, which consists of the patient's smartphone. This communication must be done efficiently, with low energy consumption, thus increasing the autonomy of the wearable device. The second stage consists of the signal receiver, which due to the advancement of mobile technologies, can be the patient's smartphone. In this stage, ECG processing is performed to identify the presence of abnormalities in cardiac activity. If an abnormality is found, the smartphone notifies the user and information about the current health status of the patient can be sent to a server located at the medical facility, which is the third stage of the system. With the patient's health information on the server, it is possible to conduct more accurate analyzes and review the decisions made by the algorithms of the second stage. The fourth step consists of the personal computer of the physician or health professional. At that moment, information about the patient's health is presented to the professional who will be able to give the proper diagnosis and take action for the treatment of the patient.

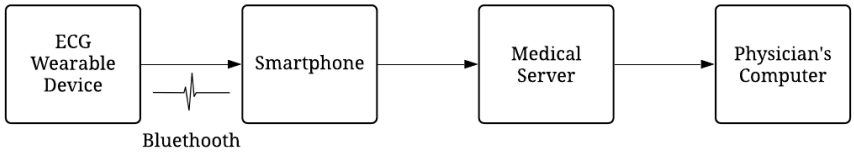

Fig. 1: ECG mobile health monitoring system.

Within the context of the first and second step of the system presented in Fig. 1, this work proposes the implementation of an acquisition step of the ECG signal as well as its processing in a android smartphone. Specifically it is intended to

i) Carry out the ECG signal acquisition through the BITalino® HeartBIT BT platform and transmission of the signal to an Android device using Bluetooth technology.

ii) Implement in the android device a segmentation algorithm to perform R peak (heartbeat) detection; and

iii) Implement in the Android device an algorithm that is able to detect the presence of atrial fibrillation in segments of the ECG signal.

2 Problem Formulation

HeartBIT is a pre-assembled bundle designed for ECG and Photoplethysmography (PPG) data acquisition and can be used as a wearable device to acquire the ECG signal. With the help of API's made available by BITalino® it is possible to establish a reliable Bluetooth communication between the wearable device and the Android device, in this case a smartphone. After receiving the ECG signal the first step of signal processing to be performed in the smartphone consist of detecting the sample of occurrence of the R peak (heartbeat) over the ECG signal. There are several techniques to perform this task among which stands out those based on neural networks [3], wavelet transform [4], filter banks [5]. An overview of all these techniques can be found at [6]. Several methods are employed in the detection of atrial fibrillation episodes on an ECG signal [7]. With

development of computer technology most of these methods rely on Machine Learning algorithms (ML) to detect and classify atrial fibrillation occurrence. Different features (also called digital biomarkers [7]) of the ECG signal can be used to detect AFIB. Some of them are extracted in the time-domain [8], [9], frequency domain [10], time/frequency domains [11], [12] or non-linear domain [13]. Each method implements a different type of learning algorithm that can perform supervised, unsupervised, or even reinforcement learning.

3 Proposed Implementation

The QRS detection step will be performed by the algorithm validated in [14], [15]. This algorithm applies to the ECG signal a band-pass FIR filter, with a passband between 5Hz and 15Hz.The derivative operation is applied to the filtered signal, followed by a normalization step and a non-linear transformation such as the Shannon energy. Moving average filters, the Hilbert transform and strategies to avoid long periods of silence in the ECG signal are also applied, until finally the moment of occurrence of a QRS complex is signaled.The details of all the steps used for the detection of the QRS complex, as well as the validation of this methodology can be found in [14]. The next stage of the proposed implementation is to implement the algorithm for detecting atrial fibrillation episodes proposed by [14]. The algorithm consists of using a neuronal network, capable of classifying the rhythm of the ECG signal segments between "normal", "AFIB" or "other rhythm". From the ECG signal and annotated R peaks some features were extracted to serve as a input to the Machine Learning model. These features consist of 60 RRI intervals (One RRI interval consists of the difference, in seconds, between two adjacent R peaks), as well as the Shannon's entropy of the individuals U, T, and P wave between every R to R interval. These entropy's features were then normalized using a slightly different method than the one used in [14]. For each RRI segment the normalization of the entropy vector was performed considering the absolute maximum value of entropy found until the moment of the segment being processed, as opposed to the normalization over the entire record as done in [14]. The machine learning model is based on a Long Short - Term Memory neural network. All the details of the ML model can be found in [14]. To implement these algorithms, MATLAB® software was used. Once the expected results were achieved, the code was adapted to the standards accepted by the MATLAB Coder® application. This application is a tool capable of generating code in C and C++ language automatically. The C language code generated by this tool were then inserted into the Android Integrated Development Environment (IDE) Android Studio®. The integration of the source code in native C language with the application made in JAVA was carried out through the JNI interface (Java Native Interface). This interface allows an application developed in JAVA to be able to carry out function calls written in native language C and C++. Using all this tools a methodology to implement any MATLAB algorithm in the Android Device was established.

4 Achieved Results

So far only the R peak detection stage of the proposed implementation was tested and validated using signals from the MIT-BIH Atrial Fibrillation database(MIT-AF) [16]. Taking into consideration that the algorithm was exhaustively verified by [14], the objective here is to confirm its functionality in the android environment. In order to do so, ten minutes of five different records of the MIT-AF database were selected and used for validation. The accuracy in the detection of the R peak was calculated considering the manual annotations present in the database. Table 1 show the performance of the algorithm in terms of accuracy considering the MATLAB and the android implementation. The results prove the satisfactory functioning of the android implementation.

Table 1: Results of the R peak detection stage

Pacient	**Matlab Accuracy (%)**	**Android Accuracy (%)**
1	95,9	95,9
2	97,9	97,9
3	99,8	99,8
4	97,1	97,1
5	99,8	99,8

5 Final Considerations

Since this is an ongoing project, the acquisition step using the BITalino® platform and the algorithm for detection of AFIB episodes will still be implemented and validated. A possible obstacle in the implementation of the proposed system, consists of establishing a reliable Bluetooth communication between the wearable device and the smartphone. A pre-processing stage may be added to the system to guarantee good results even in the presence of noise. In addition, considering that the BITalino® platform works with a different sampling rate (up to 1000Hz) and different resolution compare with the database, some adaptations may be necessary to reproduce the obtained results.

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Permanent Magnet Synchronous Generator Design for Low-Speed Applications

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Abstract. This paper presents a design overview of a permanent magnet synchronous machine (PMSG) of radial flux for low-speed applications. The utilization of permanent magnets allows the reduction of the pole pitch and consequently the design of low speed machines with reduced dimensions. The design is based on an analytical approach, according to the electromagnetic theory, followed by a numerical approach using the Finite Element Method (FEM) by using commercial software. The obtained results by the analytical and numerical approaches are similar.

Keywords: Permanent Magnet Synchronous Generator · Finite Element Method · Simulation

1 Introduction

Permanent Magnet Synchronous Generators are already a consolidated path to convert mechanical energy in electrical energy, but most of the studies are focused on large applications, improving costs and efficiency [1], [2], [3] and [4].

A low-speed generator can be useful on wind turbines because it allows a direct-driven configuration, which reduces mechanical losses and operational maintenance linked to a gearbox.

The urban wind turbines can be placed on top of buildings, houses in the hills, or telecommunications towers, reducing partially the grid-power demand.

Some urban applications with different designs and machines were developed e.g. Avant Innovations^{TM} [5] Garde uses a vertical axis wind turbine with an induction generator, Li et al. [6] studied differents winds turbines for urban applications and Longo et al. [7] has created a perspective for applications of vertical axis wind turbines.

Under the context introduced above, this paper presents the design of a 5 kW rare earth (NdFeB) permanent magnet synchronous generator (PMSG), 400 V (line-to-line). The rated speed and consequently, the number of poles is chosen based on the wind speed, the tip speed ratio of the wind turbine to be adopted, assuming a direct driven operation mode. For this specific case, it was chosen 240 rpm and 10 poles. The design approach was developed based on consolidated methodologies presented on [8], [9], [10] and [11].

As a design limitation, the model does not incorporate a thermal simulation, the temperature was assumed to be constant, equal to 80°C.

This paper is organized as follows: next section presents the main aspects of the design methodology and the obtained results; the conclusion summarizes the main results and presents the future work.

2 Methodology and Results

The problem formulation begins with the specification of the main characteristics of the machine, with its design oriented to direct drive, low power wind energy conversion systems with a power generating capacity of 5 kW, 400 V and with a power factor of 0.9.

The design methodology is based in an analytical approach, able to define the main dimensions of the machine, followed by a numerical approach, from which is possible to obtain a higher domain discretization and refined results.

The stator of the machine has 60 slots and a concentrated winding resulting on 1 coil per pole per phase with a step shortening of 5/6, as shown in the figure 1.

The machine has an inner rotor rare earth permanent magnets are mounted on the rotor surface as shown in the figure 2a.

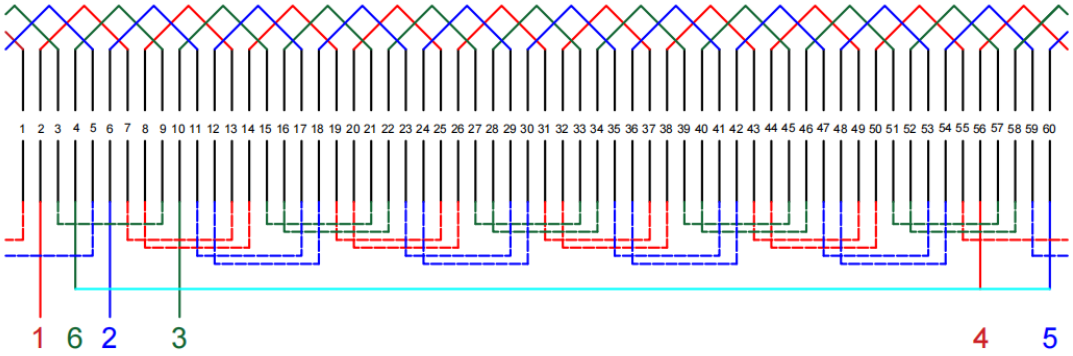


Fig. 1: Winding of the machine.

2.1 Analytical model

The analytical model returns dimensions, magnet flux, number of coils at the stator, rated stator current, stator resistance, synchronous inductance, load angle, delivered apparent power, and main losses.

This model is based on electromagnetic and circuitry formulation, as presented in [8], [9], [10] and [11] and considers the synchronous inductance, the Foucault, hysteresis, and Joule losses which approximate the model closer to a real generator.

The current density was chosen as 6.5 A/mm^2,for a given rated power,the copper losses could be reduced also increasing the rated voltage, or increasing the power factor, both reducing the nominal current.

The small load angle suggests that the machine could be able to support sudden variations caused by wind gusts. It is important because small wind generators usually does not have brakes or pitch angle variation devices.

The main results of the analytical model are shown in Table 1.

Table 1: Analytical model return values.

Results	**Symbol [Unit]**	**Value**
Apparent Power	S [kVA]	5.5
Power factor	PF	0.9
Load Angle	σ [elec deg]	15.6
Line-to-line voltage	V_l [V]	396.8
Current	I [A]	8.1
Frequency	f [Hz]	20
Armature resistance per phase	R_A [Ω]	4.4
Synchronous inductance	L_{sync} [mH]	112.5
Load	Z [Ω]	25.5+j12.4
Number of coils per slot	N_C	81
External diameter of stator	D_{se} [mm]	340.8
Airgap lenght	L_{ag} [mm]	2
External diameter of rotor	D_{re} [mm]	250
Internal diameter of rotor	D_{ri} [mm]	201
Permanent magnet base diameter of rotor	D_{rbi} [mm]	230
Radial height of the permanent magnets	h_{pm} [mm]	10
Lenght of the permanent magnets	L_{pm} [mm]	51.9
Axial length of active material	L_A [mm]	94.9
Iron losses	P_{fe} [W]	23.5
Copper losses	P_{cu} [W]	871
Efficiency	η [%]	84.7

2.2 Numerical model

The numerical model was implemented in the commercial software "ANSYS Maxwell" which uses the finite element method (FEM). The main advantage of this tool is that it performs extremely accurate simulations because it allows to do a domain discretization.

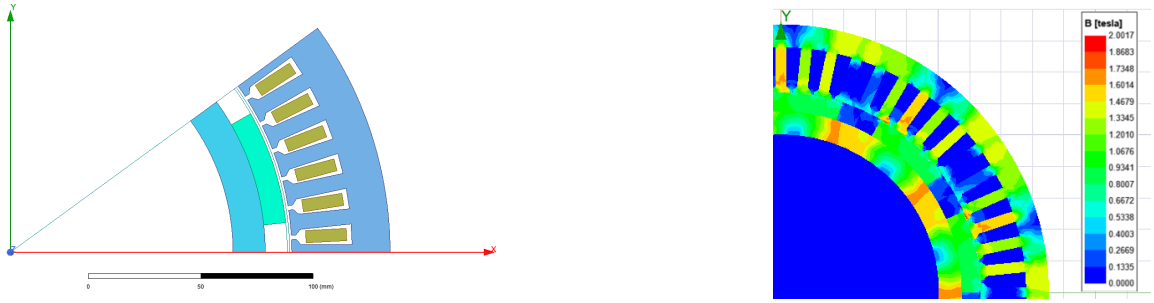
The machine was simulated creating a model on "Ansys RMXprt", a template-based electrical machine design tool, which was then exported to "Ansys Maxwell" to use the tools and analyze the design. Some results such as the design of a pole and the magnet flux densities are presented in the figures 2a and 2b.

The simulation results show that the analytical model could be used to do a preliminary study for the design of a new machine, less than 5% of difference was verified comparing the analytical model and the simulations. These differences could be acceptable because, in the analytical model, some simplifications are made, such as the infinite permeability of the soft iron, which can be easily included in simulations.

The main results of the simulation and the comparison with the analytical model are shown in the table 2.

Table 2: Simulation design return values.

Results	**Symbol [Unit]**	**S.Value**	**A.Value**	**Diff. [%]**
Line voltage	V_l [V]	416.47	396.832	4.71
Current	I [A]	8.37	8.083	3.43
Load angle	δ [elec deg]	14.307	15.647	9.36
Sync. inductance	L_{sync} [mH]	110	112.494	2.26
Apparent power	S [kVA]	6.038	5.556	7.95



(a) One pole section of the designed PMSG.

(b) Flux densities on one quarter of the machine.

Fig. 2: Obtained machine design.

Figure 3 shows the line-to-line voltage, the phase voltage and the current when the generator is connected to a XPTO load.

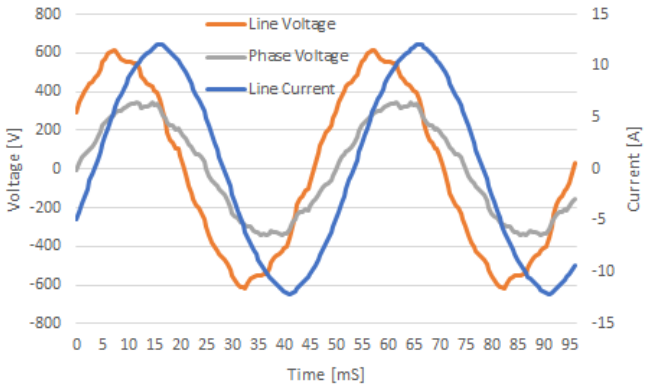


Fig. 3: Phase voltage, line voltage and line current.

3 Conclusions

This paper presented a design overview of a radial flux permanent magnet synchronous generator (PMSG) for low speed direct-driven applications. An analytical model design was used to obtain a 5 kW machine with 400 V, 240 rpm, and 10 poles and a simulation was used to refine it.

The main advantage of the used methodology, creating an analytical model and validating it through FEM is that it is possible to obtain the macro sizing of the machine using physics simplifications, from which it is easier to interact with the model, and then obtaining accurate results correcting the simplifications with the simulations that allows a domain discretization.

Future developments of this work are the incorporation of an algorithm of optimization in this model, in order to reduce costs, materials and improve machine efficiency.

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Medication dispensing system architecture

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Abstract. Non-adherence of prescribed medication is a global problem that affects many people. There are many factors related to this problem that contributes to further increase the problem and impact in a patient's life. It is proposed a system to assist in the management of medicine and the communication with carers. The system has many components that include mechanical components, electrical components and management system, and servers. It is intended to offer a system that can help reduce the non-adherence factors and the consequences in the life of the patients and their carers.

Keywords: pill management · non-adherence · system architecture

1 Introduction

Many people take pills in a daily basis, due to chronic diseases or other problems. The regular intake of the medication, at the correct dose and time helps keep a good health status and controlling the diseases. When the medicine is not taken the consequences can be dire, affecting the patient in different areas, the health, finances, social relations, and the society as a whole.

It is essential to understand what is the non-adherence to the prescribed medication and the factors that can cause it. As defined by World Health Organization (WHO) (2003) [4], reasons for non-adherence can be broadly classified into:

- **Patient factors** - factors related to functional impairment, cognitive decline, depression, social isolation, lack of acceptance of the disease and understanding of the prescribed medication and perceived benefit-burden analysis.
- **Medication factors** - factors associated to adverse effects, interactions, multiple doses per day;
- **Health care provider and health care system factors** - factors connected to lack of communication, lack of patient education and lack of follow-up.
- **Socioeconomic factors** - factors linked to the lack of carer or large carer burden.

The system presented in this paper aims to give a solution to the factors indicated by WHO. There is a need for a medication management tool, that also have communication features. It is important to provide affordable tools and services to patients that have problems adhering to their prescribed medication. This paper presents the architecture of a system that can assist patients in the medicine intake. The system should require minimal input from the user, and notify when is time to take the medication, providing

the correct dose of pills. This system will help the user manage the complex medication and save all data in the cloud, where the carers can access it.

The communication with carers is essential to reduce the their burden and stress, ensuring and informing when the doses are taken, alerting and notifying in case of an emergency. Many patients that are not able to keep up with their medication live alone and distant from any help, and this system will ensure that they can continue their normal life and receive assistance when is needed.

Non-adherence of prescribed medication is a global problem, WHO (2003) reported that the rate of adherence of prescribed medication in developed countries is around 50%, and in underdeveloped countries this rate is even lower. It is intended to help increase this rate. Furthermore, the consequences of non-adherence can be devastating, the Organisation for Economic Co-operation and Development (OECD) (2018) [1] report indicated that the poor adherence and health complications that comes, are estimated to cost EUR 125 billion per year in Europe, with nearly 200 000 (200K) premature deaths per year. The costs includes avoidable hospitalizations, emergency care, and outpatient visits. The consequences of non-adherence can affect the patient that must take the medicine, their family and the governments, when there many people suffering from this problem. Currently, there are devices in the market with similar features. However, these machines lack security features, when the medication is not conserved in the original blisters and the storage is not efficient. There is also a lack of communication features. With the system proposed it is possible to have modules with different compartment sizes and store the medication more efficiently, the device is capable of receiving information from outside servers, process it and save that data. After each task, the information is updated and the log is sent to the server also to update the external information. The asynchronous system allows the information in the dispensing system and server to be different until the connection is established.

The paper is organized as follows. The Section 2 presents the system architectural design and conclusions and future work are described on Section 3.

2 Architectural Design

This work proposes a system to aid in the medication management, give alarms and provide the correct dose to the patient in the correct time. The system compromises mechanical components (actuators), that are controlled by a management system, which is connected to a server. The system is based on Internet of Things (IoT), with interrelated devices and different components. Roberta De Michele and Marco Furini (2019) [3] stated that the benefits of IoT in the health sector can assist with cost reduction, better accuracy, medicine tracking, improved efficiency, geographical independence and real-time monitoring. It is proposed a combination of technology available to create a system that will help the patients and the carers with the non-adherence of prescribed medication.

2.1 Mechanical Design

The medication dispensing system is comprised of two parts, the dispensing module and the dispenser. The main objective would be for the machine to be able to store the user's

medication for a month without the need for refilling. Thus, the developed dispensing module considered efficiency of space, and each module stores the medication within the original blisters. This module works through an electromechanical system, consisting of an electric motor that activates a rack-and-pinion system that will rotate the central part where the pills are stored, letting them fall into a dispensing chute. The module is made up of several parts: base, which stores the pills and where there is also a snap guide for fitting into the dispenser, the electromechanical system, where, in addition to the functioning of the system there are also the dividers for the pills, and a lid. One of the electrical connectors present throughout the project is also part of this set, which will connect to the entire electrical part of the project. The main advantages of this modular system are the possibility of having several modules that can house different types of medication and the fact that it is easily removable by authorized personnel, since the dispenser has a lock, for medication refill effects. The goal is to simply pull it from the dispenser, through a slot for this purpose, disconnecting the two electrical connectors, one present on the module and the other on the dispenser. Furthermore, when the tablets leave the module, they will go to a delivery chute that will take them to a collection cup, where they can be easily accessed by users.

2.2 Management System Design

Among the electronic components inside the dispenser, the two main components inside are the Arduino Mega and ESP32, controlling the machine. They work together in a controller-agent configuration, where the ESP32 acts as the controller. In this context the ESP32 is responsible for giving instructions to the Arduino, which is responsible for controlling the motors and sensors. Both follow an observer pattern design to activate different components of the architecture as needed. The ESP32 is what connects the machine to the outside world. The machine, needs to get information regarding itself, and the medicine it contains: it is fetched the information using REST API, and stored locally in persistent storage available in the ESP32 as SPIFFS file system [2] in a databases with three tables:

1. **Sections** (section, medName, quantity): stores the information necessary for the management of the sections (the modules where the pills will be stored), including the medicine name and the quantity of pills inside the module.
2. **SectionLogs** (section, time, quantity): contains the logging information. It also assists in the control of the quantities of medicine. When pills are successfully released, it is not reduced the quantity in the sections table, but rather log it. Later on, to know the total amount of medication inside each module, it is subtracted all the pills that were successfully dropped to the initial amount. In this table it is stored the section, the time and the quantity of pills that were dropped.
3. **TimeManager** (medName, startDate, interval, endDate): stores the necessary data for the management of the prescription schedule. Each pill has a start date, end date, and an interval that the pills will be distributed, with that, all the schedule for the month can be built.

An important concern is that the machine should be able to run successfully without constant access to a network. This is why the architecture allows the data to be stored

locally, and only need to refresh when new information is available. Although, there could be important changes to schedules which could be needed. The machine is capable of running on its own without the constant need of contacting a server. ESP32 is responsible for completing the scheduler, fetching all the information from the server. In essence, it is collected the medicine data from each section. Next, the TimeManager is checked to verify if the pills prescription is currently active. If it is active, a search for time of the last logged drop is made. In case the time difference from the current time is greater than the interval of the prescription, Arduino is instructed to drop a pill, from that specific section.

There is a need for a communication channel between the ESP32 and Arduino. To accomplish this task it was used a universal asynchronous receiver-transmitter(UART) channel. The next important step was to decide on a format for a message. The message protocol is as follows: [C-V-L-P]. C = Command to be executed (int), V = Version of the protocol (int), L = Length of the parameters (int), P = Parameters of the command (string), when its alarm P = [M, N], M = motor to be activated. The message can not be sent directly as a class, so it must be either a String or send its bytes. It was decided that it would be simpler to implement it using a String, and parsing the message when it is received. Using this protocol, it allowed the micro-controllers to communicate flawlessly, having ESP32 as a the controller and Arduino as the agent, and it is possible to communicate any errors.

The logging information is important, as the logs are used to determine how many pills are still available in a section. It is also needed a way to send any important logging information from the ESP32 to the server. This will be done by sending information from the SectionLogs to the server via API. This can be used to inform a technician when medication is finished, or when there seems to be a pill stuck in the system, which is causing a blockage.

2.3 Server Design

The information associated with all the dispensers is stored in a server, installed in a IaaS (Infrastructure as a Service) cloud server. The server is developed in SpringBoot, exporting a RESTful API and supported by a relational database (PostgreSQL). In addition, the web interface is developed in Angular and Material, ensuring a responsive, fast and pleasant user experience.

The RESTful API allows synchronizing the state of each dispenser, keeping a record of the events and usage of each machine. The synchronization process is performed on demand by the dispenser after each event or launched by the technician after the replenishment of the medication. With it, the schedule is retrieved, as well as the type and number of pills in the local store. Whenever a pill is released, the information is sent to the server, together with all the events. In case of system failure, this information is restored in the dispenser. The user interface is accessed through a regular Internet browser, requiring authentication and providing adequate access control. The system follows an ACL (Access Control List) attached to a particular resource, describing what actions are allowed or disallowed.

3 Conclusions and Future Work

During the mechanical development of the device, many changes were made, from the design of the module to the final functional product capable of storing pills with the desired dimensions to the device itself. As this is still in the testing phase, there are some issues with some components that need to be revised. For example the thickness of the structural components of the device, where various components will be screwed. The gaps used throughout the design or the rigidity of the chute, that may need revision, it will increase the vibration motors efficient, when it they are used to facilitate the descent of the tablets along the chute to the collection cup is proven. On the server and management system side, there is need for further development and testing. The system should be autonomous and ensure that alerts and notifications are passed in case of emergency. Nevertheless, the interface with the users must be kept simple and the user inputs to a minimum. In the future the system will be validated by fifty elderly people.

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Autonomous navigation mobile robot in a simulation environment.

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Abstract. Most commercial robots vacuum use random movement algorithms and require too much time to perform cleaning, even without ensuring that the entire environment is clean. As the size of the environment increases, the guarantee of cleaning quality decreases. When performing random paths, there is a waste of energy, considering that the robot can pass several times in the same place. Few robots can efficiently carry out cleaning route planning. Creating an environment and route planning is limited only to more expensive robot models. Based on this, the development of a coverage path planning algorithm was proposed, which calculates a path to be covered in an environment, avoiding static and dynamic obstacles, in order to efficiently clean the entire site. A study was carried out on the ROS system, in which it has the necessary tools for the creation of maps and navigation, enabling the development of an optimized algorithm. The work was performed in an environment created in the Virtual Robot Experimentation Platform (VREP) simulator that represents the L2I laboratory located at ESTIG. The results obtained proved to be promising in which the algorithm could still be improved in order to reduce the number of visited cells. The algorithm is fully operational and can be used in many dynamic environments.

Keywords: Mobile Robot · Coverage Path Planning · Optimization.

1 Introduction

Autonomous robots are robots that can perform tasks in changing environments without human help to making decisions based on prior knowledge [1]. There are different types of robots such as: Articulated Robots [2], Cartesian Robots [3], Delta Robots [4], SCARA Robots [5], Mobile Robots [1], among others, which can perform numerous tasks. Autonomous robots are part of Industry 4.0, they are robots that can perform tasks in changing environments without human assistance. This work will focus on mobile robots that have three main functional characteristics: location, route planning and navigation. In this work, mapping methods based on odometry, and Simultaneous Location and Mapping (SLAM) [6] based on LIDAR [7] will be used for the robot to locate. Different route planning algorithms will be tested and analyzed, applied in a 3D environment in VREP [8], that simulates a laboratory, that is, a complex and fully dynamic environment, to improve the performance of a mobile robot.

One of the greatest difficulties of a mobile robot is the optimal route planning, because to calculate the best route it needs to be aware of the environment in which it finds itself. Locating a robot in an unknown environment is a very complex process, as it needs to scan the environment and create a map of it, just so it can locate itself and plan a route. The route planning process is very complex because in addition of having objects that make it difficult to calculate the best route, the place where it operates

can be very dynamic, people or other robots can transit in the place, which generates a chaotic scenario for the robot.

The objective of this work is to create a 3D environment in the VREP simulator and make a mobile robot capable of locating and moving autonomously in different environments, using for this a LIDAR sensor and an odometry system. For this simulation we will test navigation and obstacle avoidance algorithms. To complete this objective, other specific objectives were proposed: First, develop and apply algorithms for the autonomous operation of the mobile robot, using the Robot Operating System (ROS) framework. Then, test the algorithms developed in the VREP Simulator. Finaly, analyze algorithm results and indicate the most appropriate algorithm for the study scenario.

2 Materials and Methods

Most robots currently sold in the market use random movement algorithms and use a large amount of time to ensure that the environment is clean, the robots do not know that all spaces in the environment have been cleaned, they have an estimate of the cleaned space. Random movement algorithms end up resulting in wasted of energy and a reduction of the useful life of a robot. Few robots can perform a cleaning route planning in an efficient way, because to calculate the best route it needs to be aware of the environment in which it finds itself and only a few robots can do it. The proposed solution to this problem was using the ROS framework [9], create a coverage path planning (CPP) algorithm using the Gmapping [10] SLAM package to create an environment map using the data from the odometry and LiDAR sensor, the Navigation [11] packages : Mapserver to convert a image map into a data array, AMCL [12] used to obtain the robot's location and Move Base to obtain cost maps and be able to use the shortest route algorithms A-Star [13] and Dijkstra [14]. The algorithm was tested in a simulated environment in VREP based on the L2I laboratory located at the School of Technology and Management (ESTIG) of the Polytechnic Institute of Bragança (IPB).

3 Development of the CPP Zigzag Algorithm

To improve the operation of a mobile robot vacuum, a coverage path planning algorithm was developed. The Zigzag algorithm was developed, it uses the map_server from the navigation package to convert a map created into an integer array, after having the map array, it transform the array into a dictionary with the keys being the coordinates x,y and values ranging from 0(free) to 100(occupied). After having the data from the map, the algorithm search for the first free cells near the origin of the map to be the start point. It start making a path that follows a routine of going left or right until it finds an obstacle, after which it moves down or up, traversing the number of the cells that represents the size of the robot, and repeat again the routine, a function creates virtual obstacles along the path taken by the robot until it can no longer move. When it reaches a point where it is no longer possible to move, the algorithm search for a free cell in the map using the Dijkstra algorithm from move_base. The distance between the

last cell traveled and the free cells on the map are calculated, the cell with the smallest distance is used to restart the zigzag process. The algorithm ends its execution when there is no free cell left.

The path created by the Zigzag algorithm was based on static obstacles, if a chair has it position changed or someone passes in front of the robot, the robot will collide, to avoid collisions, a dynamic obstacle avoidance was implemented.

Using the robot's Lidar, when it detects an obstacle less than 10 centimeters, it stops, returns 30 centimeters, search in the global_costmap (updated cost map) from move_base the next free cell of the route. Two obstacle avoidance paths are calculated using the Dijkstra and A-Star algorithms. The robot follows the shortest path and goes towards the next free cell of the route, after reaching the free cell it refreshes the map and then follows the path of the zigzag route.

4 Experimental Results

For test comparison the BSA [15] algorithm was implemented, the Zigzag algorithm and the BSA algorithm were run in the same environment, both environments had static obstacles. The robot used a linear velocity of 0.7 m/s and used the angular velocity of 1 m/s. The tests were run in the VREP simulator alongside with the RVIZ [16] Viewer. The data collected were runtime, total map cells, occupied cells, cells occupied by obstacles, visited cells, unvisited cells, distance traveled, cells visited more than once and total cells visited.

Table 1: Results of running the zigzag and BSA algorithms.

Parameters	ZigZag	BSA
Runtime (minutes)	254	239
Distance traveled (meters)	333	264
Occupied cells	43122	38438
Total map cells	50160	50160
Cells occupied by obstacles	4252	4252
Visited cells	53280	41920
Cells visited more than once	10158	3482
Curves	101	231
Calculation Time (minutes)	9	1

The run time and distance traveled is an important data to be analyzed, it is directly related to the effort made by the robot, the more time and distance a robot travels, it uses more energy, which makes it less efficient. As can be seen in Table 1, the zigzag algorithm took 254 minutes to travel the route and traveled 333 meters in the environment. The BSA took 239 minutes to cover the route and covered 264 meters of the environment. The zigzag had an average speed of 1.31 meters per minute while the BSA averaged 1.10 meters per minute. The BSA had a lower speed and traveled a shorter distance than the zigzag.

Occupancy is one of the main points to be considered, as the greater the occupation, the better the cleaning is performed, one problem that robots vacuum have, is to ignore

areas near obstacles and walls, as can be seen in Table 1, the map has 50160 total cells, of which 4253 are occupied by obstacles, the zigzag when traversing the map occupied 43122 free cells which represents 93.93% of the free cells in the environment. The BSA traveled through 38438 free cells which represents 83.73% of the free cells in the environment. As seen in the previous table, the zigzag traveled a greater distance which reflects the greater number of occupied cells in comparison to the BSA.

The number of visited cells is important to determine the efficiency of an algorithm, the fewer visited cells are repeated, the more efficient the algorithm is. As can be seen in Table 1 The zigzag algorithm ran a total of 53280 cells of which 10158 were repeated. The BSA ran a total of 41,920 cells of which 3842 were repeated. BSA had a utilization of 90.84% of the visited cells while the zigzag had a utilization of 80.94% of the visited cells.

5 Conclusion

Both algorithms generate an efficient cleaning route for a robot vacuum in an environment, as we can see in the results presented in Table 1 both algorithms have pros and cons. The zigzag algorithm travel speed is greater than that of the BSA, this is because the BSA tends to make more curves with obtuse angles. The zigzag algorithm had a larger occupation on the map compared to the BSA, this happened because the zigzag algorithm has a path that runs closer to obstacles and walls, which ends up covering a larger area. By having a larger coverage area, the Zigzag algorithm had a greater number in the repeated visited cells. In proportion of cells occupied by time, the zigzag algorithm had a higher performance with 169.77 free cells per minute, the BSA had a performance of 160.82 free cells per minute. In the end, the algorithm that occupies a larger area with a relatively lower time tends to be more efficient, in the tests performed, the zigzag algorithm proved to be more efficient than the BSA, having a larger occupied area with a proportionally smaller run time. The zigzag algorithm follows an order to search for the closest free cell, which makes sense if we want it to travel a shorter distance, but it is not necessarily the most effective, as it does not travel the map in an organized way. For future work, it would be interesting if the zigzag algorithm planned a route that would go through the environment in a more organized way, thus covering fewer visited cells.

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Sustainability and Food Safety: Challenges and Impacts

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Abstract. Sustainability sits on three pillars: environment, society, and economy. Nowadays the Food Value Chains are demanded to deliver food with security and quality considering social and environment dimensions. The sustainability of Food Safety depends on its ability to supply safe products without compromise the future generations regarding social, economic, and environmental grounds. So, how can food safety comply with sustainable measures? Can the analysis of food safety risks be more flexible? In a way to understand the challenges placed by the compliant of food regulations and assure sustainable development in food retail and hospitality restaurants, will be applied a survey to several representative companies. The survey aims to identify the problematics and its resolutions for issues regarding the consumption of food before expiring date, reutilization of food, temperature and portions controls, replacement and reutilization of food packaging, as well best practices implemented to reduce food waste and other generated waste, especially plastic waste. Also, the problematic of COVID 19 will be approached to understand the impacts on these sectors, regarding food waste and waste production. Approaching these subjects, aim to identify the main challenges of being sustainable and comply with food safety rules, describing ways to mark a sustainable path without compromise public health. Therefore, the collected data will be studied to set examples and find new approaches to relate and connect both areas in a way to facilitate procedures and processes.

Keywords: Sustainable development, Food Safety, Food Waste, Waste Management, Best Practices.

1 Sustainability and sustainable development

Sustainability sits on three pillars: environment, society, and economy [1–4]. As a holistic concept, looks for the balance between human needs and what the world is capable of providing [2]. In 1987, the publication of the report "Our common future", by the World Commission on Environment and Development (WCED) defined sustainable development [2, 5, 6] as "humanity has the capacity to make development sustainable to ensure that it meets the needs of the present without it will compromise the ability of futures to meet their needs" [7].

Almost 20 years later, in 2015, The 2030 Agenda for Sustainable Development was adopted worldwide, defining 17 sustainable development Goals and 169 targets, including all three strands: environment, social and economics [6, 8].

2 Food safety and food safety management

Food Safety can be defined as the "Assurance that food will not cause adverse health effects to the consumer when it is prepared and/or eaten according to its intended use" [9, 10]. The entire supply chain, from primary producers to retailers and consumers, has a responsibility to ensure safety and suitability of food for consumption. [9] The legal obligations regarding this area constitutes one of the fundamental issue for

any food operation [11]. A Food Safety Management system comprehends several parts to manage food safety: Prevention; Preparedness (procedures/measures to ensure direct and efficient actions to protect and inform customers in case of non-compliance) and Self - Check activities [12]. Should include a Good Hygiene and Manufacturing Practices, HACCP (Hard Analysis Critical Control Points) based procedures and relevant management policies/procedures in order to ensure traceability and recall systems [12].

3 Sustainability and food safety

Nowadays the Food Value Chains are demanded to deliver food with security and quality considering social and environment dimensions [13]. On a world scale, current food production systems, with large production and consumption, represents a negative and relevant impact in environment degradation, causing extensive damages in natural systems and therefore not sustainable [14]. A sustainable food system sits on the sustainable development goals (SDG) base [3].

Regarding sustainability, food safety relates to another concept "Food Security" defined at World Food Summit, in 1974, as when "all people, at all times, have physical and economic access to sufficient, safe, and nutritious food to meet their dietary needs and food preferences for an active and healthy life." [15].

One of the strategies of European Commission to achieve 17 SDG, according to 2030 Agenda's is the creation of the "Farm to Fork" Strategy to " make food systems fair, healthy and environmentally-friendly" that is included in the European Green Deal [16, 17].

4 Food waste

It is estimated that food waste accounts about one third of the world's food production [18, 19]. According to a FUSIONS study in 2016, in Europe alone, tons of food are wasted, including food residues such as edible products [20]. One of the goals of the 17 SDGs, specifically 12.3, is to reduce food waste in retail and consumer, and food losses along supply chains [19, 21]. According to FAO, there are to definitions for food Waste:

- Food loss being the decrease in the quantity/quality of food resulting from decisions and actions by food suppliers in the chain, excluding retail, food service providers and consumers.
- Food waste being the decrease in the quantity or quality of food resulting from decisions and actions by retailers, food services and consumers [22, 23].

4.1 Food waste in retail

Food waste in retail represents 5% of Europe's total waste, inside food chain [20, 24]. Despite the lower number comparing to agriculture, retail market, by its stage in food chain, represents a key position influencing the total of food waste [24, 25]. Generally, food waste in retail is caused by incorrect product handling or storage and inaccurate predictions about consumer's needs/ buying patterns. Some frequently challenges of retailers are linked to the sale of food products that rapidly become unsalable due to

esthetics that not meet patterns expected by the consumer, namely misshapen products or with small damage, or due to the surpassed "best before" date despite their ability to be consumed/used as long as they continue aligned with health and safety standards [24].

4.2 Food waste in hospitality restaurants

In Europe, the hospitality sector generates around 1kg of food waste per day, representing the second largest source of food waste, after the consumers. Current legislation and business policies present a huge challenge for the hospitality industry to reduce food waste, as focus on product safety and end-customer satisfaction generates a reduction in the desire to develop sustainable actions. One challenge is compliance with very specific food safety legislation, greatly limiting the retention time of products and their reuse. One solution can be donation of food from excess or unsold products, to charities [24]. Other relevant issue is related to the consumer's lack of perception, in the quantities placed on the plate, which can lead to about 50% of food waste [24]. In addition, planning menus and purchasing processes are vital to minimize food waste. Storage, handling, and poor distribution can cause food deterioration. Therefore FIFO (First in First Out) rules are implemented to minimize losses. Other food waste sources are related to preparations, cooking, and serving errors and large portions [26].

A study published by the European Commission in 2018 estimated that 10% of the 88 million tons of food waste origins from the stipulated expiration dates. On this matter, EFSA (European Food Safety Authority) recently studied expiration dates including labels such as "consume until" or "consume before" conducting a risk assessment for health through the dangers presented for each type of food. The prevention of food waste is one of the priorities defined in the action plan for the Circular Economy, adopted by the European Commission in 2015 and the study to improve the use of the definition of expiration dates by food chain operators is extremely important [27].

5 Waste production and management

5.1 Plastic food packaging – Avoidable waste or needed solution?

Each year, plastic waste, followed by single-use food packaging, threatens the integrity of ecosystems creating an unprecedented waste management crisis. Packaging accounts for 40% of the plastic application market share where, where 41% correspond to food packaging [28]. Although packaging has revolutionized the food chain, allowing longer food commutes and greater convenience, single-use packaging, both for beverages and solid foods, is the most common waste found on coasts and oceans around the world [28]. Despite the negative perception of impacts whether on the environment, economy or society, food packaging helps to reduce food waste in consumers as it extends the life of the product [33].

It is estimated that only 9% of all plastic produced in the world has been recycled, 12% has been burned and the rest remains either on the soil or in the ocean. Supermarkets alone account for 40% of plastic packaging waste, claiming that packaging is necessary to keep products fresh. Plastic is not a perfect material but a necessary one.

However solutions such as biodegradable plastics or packaging reduction are being developed [29]. In Portugal for example, Auchan Group set up a sales corridor for bulk products (e.g. dried fruit) without plastic and with the option of storing the products in paper bags [30].

The circular economy promotes waste and raw materials minimization and recently this concept has gain enormous relevance in politics and has been implemented in several areas from production, consumption, or in the waste management sector. The three R's, reduce, reuse, and recycle are the most important options in waste management [31]. An example of a plastics substitute is glass. This material has several properties to ensure food safety, preservation, and quality of the product. In addition, due to its transparency, allows consumers to view the real product before purchase. Despite the benefits, glass, in terms of food safety, represents a physical hazard in food production and can harm the final consumer [32].

6 Best Practices: waste and food waste reduction

Both in hospitality restaurants as in retail there are initiatives and programs that aim to manage the major issues of today, such as food waste and waste reduction. For example:
- Replacement of plastic sticks in cotton swabs:
- Given 2nd life to food that no longer has market value (example: "ugly" fruits to make sweets";
- Food donations;
- Bulk sales (example seeds and cereals) to ensure costumer only buys the desire amount (reduce food waste) and use of paper bags to transport them and so reducing plastic.

7 Covid-19 Pandemic – Impacts in sustainability and food safety

The complexity and scope of food system, in its complexity and scope, is being affected. COVID-19 had an impact on all sectors (Fig.1). Hotel industry, for example, showing great fragility, having been forced to close many establishments. In addition, it aggravated the challenge of managing food waste, directly verified in the compulsory closure of facilities, or else in the food delivery operations of restaurants [34].

8 Methodology of study and expected results

To understand the impacts, challenges and solutions relating sustainability and food safety in hospitality restaurants and food retail it will be applied a survey to the most representative companies in Portugal in these sectors. Taking the experience and information regarding companies with sustainable culture, is expected for them to have practices that contribute to reduce plastic usage and its waste and minimize food waste, in a way to respond to constant changes and evolutions worldwide but still ensure food safety. Is expected to these companies to eliminate/replace certain materials ensuring sustainable development and maintain public health.

Waste Impact	Immediately		Short Run	Mid-term	Mid-term
Potencial Scale of Time	6 months	12 months		24 months	
	Direct		Direct	Direct	Indirect
Food	**Unfinished inventories** Due to sudden lockdown and temporary close of business		Increase of food waste – take away		Upstream Food waste due to reduction of catering and closed business
Plastic	**Increase of single use plastic (gloves and face masks in food preparation) – Hygiene requirement**		Increase of other plastics from water bottles, disinfectants and cleaning products, hand sanitizer		Increase of food packaging in food distribution (food delivery)

Fig. 1: COVID-19 Pandemic's impact in waste production – Hotel Industry (Adapted from [34])

Regarding COVID-19 is expected to observe a negative impact in terms of Sustainable Development, for example on waste production related to the single packaging.

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The A3 Problem Solving Methodology In Complaints Management

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Abstract. The ability to solve problems in a structured way and as a team is a key competitive advantage of any organization. Whether in dealing with non-conformities, in solving quality problems, in accident investigation and analysis, or even in continuous improvement projects. A3 methodology provides a practical, visual, and objective framework to characterize the problem, determine its root cause(s), and develop the most appropriate solutions based on reasoned decision making, supported by evidence, and solved as a team. The goal of this project is to apply the Lean A3 Problem Solving methodology to analyze and improve the complaints management process. This methodology allows monitoring KPI's (Key Performance Indicator), defining improvement actions, achieving goals and validating results, providing greater efficiency of the process and satisfaction of stakeholders. To solve the problems identified, improvement actions will be implemented based on the NP ISO 9001:2015 and NP ISO 10002:2020 standards and Lean methodologies and tools. Thus, transforming the problems into positive opportunities for the organization through an effective management of complaints. Improving continuously, the products/services, the processes, the reputation of the organization and consequently the organizational performance in the short and long term. It is expected to obtain an overall improvement of 15% in the KPI's under study,by implementing the improvement actions resulting from the application of the A3 methodology. The A3 Problem Solving methodology can be standardized and applied to a wide variety of improvement and problem solving projects.

Keywords: Lean, A3 Problem Solving, Continuous Improvement, Complaint Management, Customer Satisfaction.

1 Introduction

With the economic globalization that the business world is going through, the increasing competitiveness between companies, and the economic difficulties, which have been greatly aggravated by the COVID-19 pandemic, there have been some weaknesses in organizational structures. In response to these organizational weaknesses, the implementation of a Lean philosophy, which aims at eliminating waste (*Mudas*), solving problems and continuous improvement, becomes an irrefutable competitive advantage.

It is tacit that customers are an asset to any organization, it is for them that they work and generate value. The customer must be seen as a decisive strategic factor that must be treated with care, preserving the good relationship between the parties. All companies that believe that it is good not to have complaints, and that when they do have them do not deal with them properly, are not thinking of their customers as the future, they do not think of a complaint as an opportunity to build customer loyalty and as an opportunity for improvement.

This project aims to combine the requirements of the NP ISO 9001:2015 standard and the NP ISO 10002:2020 guidelines with the implementation of the A3 Problem Solving methodology, in order to effectively manage the claims management process,

detect and eliminate the root cause(s) of the problem and consequently ensure greater satisfaction of all stakeholders and continuous improvement of the process.

2 State of the Art

Studies indicate that organizations' responses to customer complaints are often unsatisfactory, resulting in customer disappointment and loss [1]. Notwithstanding the complaints they receive, organizations ignore the inputs to them, and as a result, many complaint processes seem geared toward trying to calm customers rather than ensuring that problems do not recur [2].

Discovering the root cause(s) of problems is not always an easy task, and is often neglected by organizations, who mistakenly choose to perform corrections or also called containment actions, rather than performing corrective actions. The solution lies in closing the gap between the actual condition and the standard, which goes far beyond performing containment actions [3].

To address this shortcoming Toyota created the A3 problem solving approach, which is based on the kaizen philosophy [4]. The basic concept of the Lean A3 methodology is to communicate only the most pertinent information in a simple visual format, it is used to develop consensus among the work team [5] and is a way to stimulate skill development in employees [6]. It is also one of the main methodologies used to identify waste in activities and processes, and a valuable aid for designing and standardizing continuous improvement projects [7]. The A3 report is a powerful tool; it establishes a concrete framework for implementing PDCA (Plan, Do, Check, Act) cycle management, thus helping to gain a deeper understanding of the problem or opportunity. It establishes a guideline on how to deal with that problem and facilitates cohesion and alignment within the organization on the actions to implement [6]. The focus of the method is on a step-by-step approach, which includes other different methods that lead to the actual root cause of the problem, if applied correctly (see table 1) [8].

The A3 report may have distinct sections, however, the sections that are by rule most commonly used are: Background; Current Condition; Objectives; Root Cause Analysis, Target Condition, Implementation Plan, and Follow-up (see table 1) [4, 6, 9].

The A3 Problem Solving methodology is further characterized by seven elements: Logical thinking process; Objectivity; Synthesis, Separation, Visualization; Alignment; Internal coherence and external consistency; Systemic Viewpoint [6].

3 Methodology

In this research project we chose to use the empirical qualitative and quantitative methodology, based on a case study. The case study consists of the application in real context of the A3 Problem Solving Methodology in Complaints Management in two service provider organizations. The study will be developed in a city council and a water supply and wastewater sanitation company.

In the initial phase of the project, and in order to better understand some of the concepts, methodologies and tools that will be applied, a systematic search of biblio-

Table 1: Goal of each section of A3 and examples of Methods and Tools that can be used

Section	Example of Methods/Tools	Goal
Background	Quality studies, KPI's; Suggestions; Weighting Grids; Pareto Charts; Histograms; A3; 8D or similar reports.	Characterize the background and importance of the problem to the organization's context.
Current Condition	5W2H; "Is -Is Not"; Control Charts; Histograms; Pareto Charts; Records; Quality Surveys.	Characterize the problem in detail.
Objectives	Tracking Charts; Control Charts; Pareto Charts; Histograms.	KPI's Quantify the improvements achieved, using the same KPI's.
Root Cause Analysis	Ishikawa; Cause and Effect Diagram; 5w; Weighting Matrix; Brainstorming.	Identify and validate the root cause(s) of the problem.
Target Condition	Brainstorming; Multicriteria Diagram; Decision Tree; Weighting Grid.	Select the corrective solutions to eliminate the root cause.
Implementation Plan	5W2H; Tracking charts; Test reports; Logs.	Define the 5W2H and implement the actions.
Follow-up	5W2H; Lessons learned.	Standardize effective solutions, prevent recurrence, and disseminate good practices.

graphic information sources was conducted in scientific databases, based on the keywords: Lean, A3 Problem Solving; Continuous Improvement; Complaint Management; Customer Satisfaction.

The second phase of the case study, and already integrating an A3 problem solving and continuous improvement perspective, will apply the DMAIC method, which is divided into five key steps [7, 10]:
1- Define -Through the analysis of the direct KPI's of the process performance (see table 2), the categories of complaints and the results of the diagnostic audit, brainstorming sessions were carried out with the work team to identify the main inefficiency problems and then define the specific problem to be studied.

2- Measure - Quantify all key information or KPI's related to the object of study, the collecting information will allow the team to focus on specific areas.
3- Analyze - Segment each level of information and understand the possible root causes that lead to lower efficiency and greater dissatisfaction of stakeholders.
4- Improvement Actions - Implementing the necessary project actions to improve the system, namely through new ways of doing things, cheaper, or faster. Quantitative methods should be used to validate the implemented actions.
5- Control - Monitor and evaluate the effectiveness of the improvement actions taken and control the stability of the new system implemented.
The third and last phase of the project consists in the analysis of the data and results obtained with the application of the case study and its conclusions.

In addition to this project, a database for categorizing complaints will be developed, as well as the necessary templates for the application of the A3 methodology (for

Table 2: Direct KPI's of the complaint management process performance

KPI's	Metrics
Number of Complaints Received	$\sum Number\ of\ complaints$
Repeat Complaints Rate	$\frac{Nº\ of\ Repeated\ Complaints}{Total\ complaints} * 100$
Number of recurrent problems that had no complaints	$\sum Nº\ of\ Problems\ that\ Recurred\ and\ had\ no\ complaints$
Rate of Complaints Solved on Time	$\frac{Nº\ Complaints\ resolved\ on\ time}{Total\ complaints} * 100$
Rate of Complaints that were incorrectly prioritized	$\frac{Nº\ Complaints\ with\ incorrect\ priorities}{Total\ complaints} * 100$
Rate of Improvement due to complaints	$\frac{Nº\ of\ Improvements\ due\ to\ Complaints}{Total\ of\ improvements} * 100$
Complaints resolved after the agreed-upon deadline	$\frac{Nº\ of\ claims\ resolved\ after\ the\ deadline}{Total\ complaints} * 100$
Rate of Complaints referred for external resolution methods	$\frac{Nº\ externally\ resolved\ complaints}{Total\ complaints} * 100$

example: Kick-off; A3 Report; Is-is not; Multi-criteria Method; Action Plan - PDCA and Preventive and Corrective Action Tracking). A tool will also be implemented in order to assist the correct prioritization of complaints (for example GUT Matrix).

4 Expected Difficulties

The main difficulties in carrying out the case study were expected to be the application of the methodology itself, since in order to be applied effectively the moderator must have experience in the methodology, be familiar with the process, know the context of the organization and also have knowledge of coaching. Another expected difficulty is the resistance on the part of organizations to the implementation of a "complaint culture", since complaints tend to be seen only as problems.

5 Expected Results and Conclusions

It is expected to obtain an overall improvement of 15% in the KPI's under study, however, it is expected that in the case of organizations that have a weak "Complaint Culture" that the number of complaints will tend to increase. This increase is not necessarily negative, these values may be a reflection that the process is effectively effective and not of problematic products or services, since after an implementation or re-fresh to the complaint management process is usual [11].

It is also expected that this project will contribute to compliance with current legislation and regulatory requirements in the area of complaints. As well as to promote a strategic management of customer focus and an adequate management of requirements and expectations of all stakeholders.

The A3 Problem Solving methodology can be standardized and applied to a wide variety of improvement and problem solving projects.

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Implementation of a navigation system for a mobile robot in a dynamic environment using AR tags to increase localization accuracy

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Abstract. Mobile robotics is one of today's fastest expanding scientific fields, having applications in numerous areas. One of the main areas of study within mobile robotics is in the localization and navigation of robots within an environment. Simultaneous Localization and Mapping (SLAM) strategies are widely used in solving problems involving navigation, however, SLAM algorithms do not have excellent position estimation in dynamic environments where obstacles are present that constantly change position. Aiming to obtain better results in the localization of mobile robots using SLAM algorithms, this paper presents an approach that aims, through the detection of augmented reality tags positioned in a simulation environment, to increase the accuracy of the determination of a mobile robot on wheels. To this end, the ar_track_alvar package with ROS integration is used, which makes it possible to accurately determine the relative distance between a tag and a camera. This way, when a camera is positioned on a robot it is possible to determine its distance and orientation in relation to tags positioned at fixed points in the environment, in order to use this information to decrease the localization error of the SLAM algorithm. A comparison of the results obtained when navigating the robot between different points using SLAM, before and after the tags was applied, was then performed.

Keywords: Robotics · Simultaneous localization and mapping · ROS.

1 Introduction

Autonomous mobile robots have the ability to move independently, making decisions based on data collected from the environment so that they can perform tasks without the human interference. Today, mobile robots are applied in numerous fields such as industry, agriculture, medical care, space exploration, security, delivery, autonomous vehicles, construction, among others [9].

One of the biggest difficulties in mobile robotics is found in localization. Estimating the actual position of a robot in the environment as well as the target position is something that requires knowing and relating the elements existing in the environment and their respective positions through mapping strategies [3].

Simultaneous localization and mapping techniques, also known as SLAM, are commonly used so that it is possible to simultaneously generate a map of the environment explored by the mobile robot and determine the location of the robot and surrounding landmarks, enabling an adequate path planning [6].

The Robot Operating System (ROS) has numerous packages to perform SLAM, such as the gmapping SLAM package that allows you to generate maps using a laser sensor or a depth camera, while the probabilistic AMCL (Adaptive Monte Carlo localization) package allows to perform the localization of the robot based on information provided

through the laser sensor and data from the robot's odometry [4]. However, SLAM does not work so well in dynamic environments, since choices such as furniture that are repositioned or even people moving around can interfere with the robot's position estimation since the laser sensor reading will vary from the data obtained in the creation of the map. Another factor is that the robot's odometry is not always accurate enough to perform the navigation [5].

Given the lack of precision in locating mobile robots in dynamic environments, this article presents an approach to increasing the accuracy of locating a simulated mobile robot positioned in a hall, where augmented reality (AR) tags were distributed on the ceiling so that from the detection of them it would be possible to determine the robot's position in the environment, to integrate the position data obtained to the SLAM algorithm, increasing its accuracy. At the end of the work it is hoped to obtain better navigation results with the robot within the simulation environment, so that the same algorithm can be tested with real robots in future work.

After the brief contextualization presented in this section, section 2 will briefly talk about AR tags and their use in navigation systems. Section 3 describe the approach developed to improve a SLAM algorithm applying tag detection. In section 4 the results obtained will be shown, and finally, section 5 presents the conclusions and future work.

2 Related work

In this section will be introduced briefly, about the ROS package ar_track_alvar and some applications of AR tags in localization systems.

2.1 Ar_track_alvar

The ar_track_alvar is an integration package for ROS for an Open Source Alvar AR tag tracking library. It allows the creation of different two-dimensional tags consisting of a 5x5 square of white and black pixels with a border of black pixels [5]. In Fig. 1 some tags are presented.

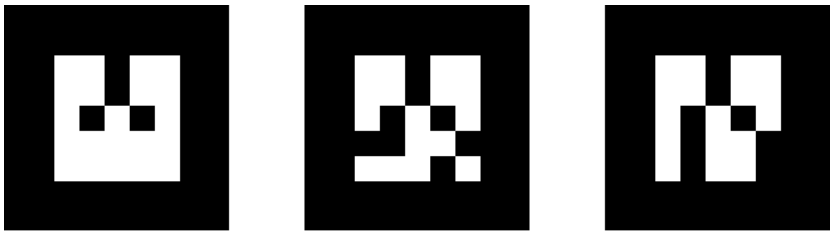

Fig. 1: Example of Alvar tags that encode ids 0, 1 and 2 respectively.

Each tag is encoded with its id, so it is possible to use the package to identify each tag, in addition, it is possible to precisely determine the distance and orientation of the tag in relation to the camera used for its visualization, even in different lighting conditions [8]. This way, when positioning a camera over a robot, for example, and

knowing the position that a tag occupies in the environment, it is simple to know the position in which the robot is.

2.2 Use of AR tags in localization algorithms

Considering that AR tags detection provides excellent results in determining the distance between them and cameras, it is common to find several applications that use them in location systems. Piardi [7] makes use of tags placed on robots and a camera placed on the roof of a small-scale warehouse as a way to determine the position of robots in the warehouse while transporting products.

Zhao [1] used augmented reality tags as markers in performing autonomous drone landing, where the drone uses them to determine its distance and orientation relative to the landing point. Ernst [2] features a practical implementation when using the detection of tags placed on walls to improve performance in navigation and location of a turtlebot in a small environment.

The versatility of using AR tags, as they can be placed in different locations, and the precision in determining their position were determining factors in their choice to implement the approach presented in this article.

3 Mapping and Navigation

A scale representation of the CeDRI (Research Center in Digitalization and Intelligent Robotics) hallways, located at the Polytechnic Institute of Bragança, was projected in the robotic simulator V-REP. A mobile robot was placed in the environment, which has a LIDAR sensor (Light Detection And Ranging) and a camera that is responsible for viewing the AR tags that were placed on the ceiling.

Using the LIDAR sensor and the SLAM gmapping package, an environment map was created by guiding the robot through the corridors. In Fig. 2, the generated map of the environment is presented.

With the generated environment map, an algorithm in Python was implemented to determine the robot's position in the environment according to the distance between an identified tag, the camera positioned on the robot, and the coordinate where the tag is positioned in the environment. Once the robot's position is provided, the information is sent to the AMCL algorithm which uses the information to best estimate the robot's position, when necessary. The robot's position is then used by the navigation algorithm, which uses the ROS package move_base, to perform the robot's movement to the desired destination, further using the information from the LIDAR sensor to perform the steering deviation.

In total, 22 AR tags were placed on the environment ceiling, so that they were assigned to reference points used in the implemented Python algorithm responsible for determining routes between different points in the environment. It is important to know that there are places where will be no tag in the robot's field of view, so at these points, the robot's location will depend exclusively on the AMCL probabilistic algorithm.

Placing a larger number of tags could solve this problem and ensure that the robot's location remains accurate at any point in the environment. However, the scenario was

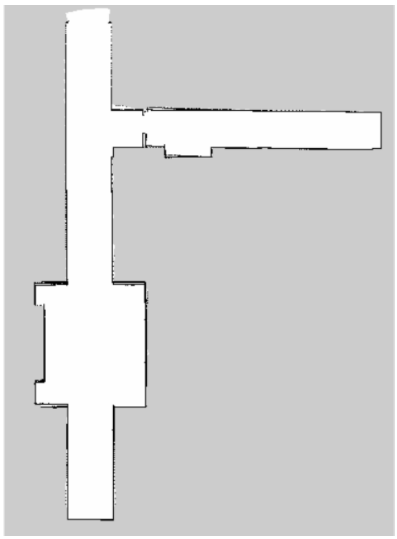

Fig. 2: Environment map generated by SLAM gmapping.

designed to be reproduced in the real environment later, which presents places that do not allow the position of tags, such as light bulbs for example. Another factor is that while in the simulation it is possible to correctly position the tags in the desired coordinates, the same does not occur in the real environment, since mistakes can be made during the positioning of the tags, moving them wrongly.

Therefore, we tried to use the smallest number of tags possible, opting to leave places that do not require as much precision in the robot's location without the presence of tags.

4 Preliminary Results and Discussion

From tests carried out in the simulation environment through the developed algorithms, it was possible to carry out the robot navigation between different points in the environment with excellent precision. When making use of the SLAM algorithm without performing tag detection, during navigation the position estimated by AMCL reached errors ranging from 50 cm to 1.40 m in some attempts.

In places where there were tags in the camera's field of view, the position and the robot could be determined without major discrepancies, where they remained at an error of less than 2 cm, in relation to the actual position. In places where there were no tags, the discrepancy sometimes increased to an error of 7 cm, despite being a small value, it is important to take into account that here the AMCL probabilistic algorithm has access to excellent odometry data, since the robot's odometry simulated has practically no errors.

In a real robot, the odometry is not so accurate, which would make the error of the position estimated by AMCL even greater. At the same time, the data obtained by the real LIDAR sensor also has more noise than the simulated one, which would also interfere with the AMCL algorithm.

5 Conclusions and future work

Using AR tags to improve the location of mobile robotics in an environment has been shown to be a great alternative to ensure a better precision in navigating between different points.

As a next step in the implementation of the system, tests with moving obstacles are expected to be carried out, to verify the accuracy of deviations of the same methods from the features present in the move_base package. And then start performing tests in the real environment, checking the accuracy of navigation when using a real robot.

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Optimal Energy Management of a Microgrid System

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Abstract. A smart management strategy for the energy flows circulating in microgrids is necessary to economically manage local production and consumption while maintaining the balance between supply and demand. Finding the optimum set-points of the various generators and the best scheduling of the microgrid generators can lead to moderate and judicious use of the powers available in the microgrid. This work aims to apply an energy management system based on optimization algorithms to ensure the optimal control of microgrids by taking as main purpose the minimization of the energy costs and reduction of the gas emissions rate responsible for greenhouse gases. The approach is based on a multi-objective optimization approach based on the Pareto-search algorithm that deals with the optimization of the two functions: cost and gas emission simultaneously providing a set of non-dominated points that represent different scheduling scenarios of the microgrid system. Numerical results are presented and discussed.

Keywords: Renewable Energies · Microgrid · Hybrid Energy System · Energy Management System · Optimization Algorithms.

1 Introduction

Aiming to increase the penetration of renewable energies and solve the problems associated with the conventional electrical system such as losses in the transport and distribution networks, the microgrid concept has been introduced to ensure reliable production on a small scale, by making the place of consumption a place of production [3, 6]. The microgrid is defined as a low-voltage distribution network including various distributed generators (micro-turbines, fuel cells, photovoltaic, wind-turbines, among others), together with storage devices and controllable loads that can operate interconnected or isolated from the main distribution network. Microgrids become a component of smart grids, where a load management system is used to balance the energy generation and consumption [2, 4]. The optimal energy management system can effectively optimize, improve efficiency, provide flexibility, controllability and economic viability of power system operation [1]. Several management systems strategies based on optimization approaches have already been proposed, for instance, the authors in [5] have adopted stochastic uni-objective approaches. Other authors have considered the energy management in microgrid as a multi-objective optimization problem considering both economic and environmental aspects.

The remaining parts of the paper are organized as follows: Section 2 describes the proposed microgrid system and formulate the optimization problem used for its treatment and these constraints. In Section 3 we present and discuss results obtained under

the computational simulations. Section 4 concludes the study and proposes guidelines for future works.

2 Problem formulation

The chosen microgrid consists of two renewable sources photovoltaic (PV) and wind-turbine (WT), a conventional source micro-turbine (MT), and an energy storage system (ESS) in addition to the load. The whole microgrid is connected to the main grid through a transformer and common coupling point (PCC). The energy management system of the proposed microgrid is formulated as an optimization problem based on economic and environmental objective functions as described as follows

2.1 Energy price evaluation

The main objective of the cost function is to satisfy the demand of load during the day in the most economical way. So, in each hour t the cost function ($C(t)$) can be calculated as:

$$C(t) = \sum_{i=1}^{N_g} P_{DGi}(t) B_{DGi}(t) + \sum_{j=1}^{N_s} P_{SDj}(t) B_{SDj}(t) + P_g(t) B_g(t) \tag{1}$$

where N_g and N_s are the total number of generators and storage devices, respectively. The $B_{DGi}(t)$ and $B_{SDj}(t)$ represents the bids of i^{th} DG unit and j^{th} storage device at hour t. $P_g(t)$ is the active power which is bought (sold) from (to) the utility at hour t and $B_g(t)$ is the bid of utility at hour t.

2.2 Emissions evaluation

In addition to the operating cost, the aspect of greenhouse gas emissions is also taken into consideration. The emission objective function consists of the atmospheric pollutants such as nitrogen oxides NO_X, sulfur dioxide SO_2, and carbon dioxide CO_2. The mathematical formulation of total pollutant emission in kg can be expressed as:

$$EM(t) = \sum_{i=1}^{N_g} P_{DGi}(t) EF_{DGi}(t) + P_g(t) EF_g(t) \tag{2}$$

where $EF_{DGi}(t)$ and $EF_g(t)$ are GHG emission factors which described the amount of pollutants emission in kg/MWh for each generator and main grid at hour t, respectively.

The energy management optimization problem can be defined as follows:

$$\min_{(P_{DGi},P_{SDj},P_g)} \quad \left\{ \sum_{t=1}^{T} C(t), \sum_{t=1}^{T} EM(t) \right\} \tag{3}$$

$$s.t. \quad \sum_{i=1}^{N_g} P_{DGi}(t) + \sum_{j=1}^{N_s} P_{SDj}(t) + P_g(t) = P_L(t) \tag{4}$$

$$P_{DGi}^{min}(t) \leq P_{DGi}(t) \leq P_{DGi}^{max}(t) \text{ for } i = 1, ..., N_g, \tag{5}$$

$$P_{SDj}^{min}(t) \leq P_{SDj}(t) \leq P_{SDj}^{max}(t) \text{ for } j = 1, ..., N_S, \tag{6}$$

$$P_g^{min}(t) \leq P_g(t) \leq P_g^{max}(t) \tag{7}$$

The optimization model used in the energy management system is illustrated in Fig.1.

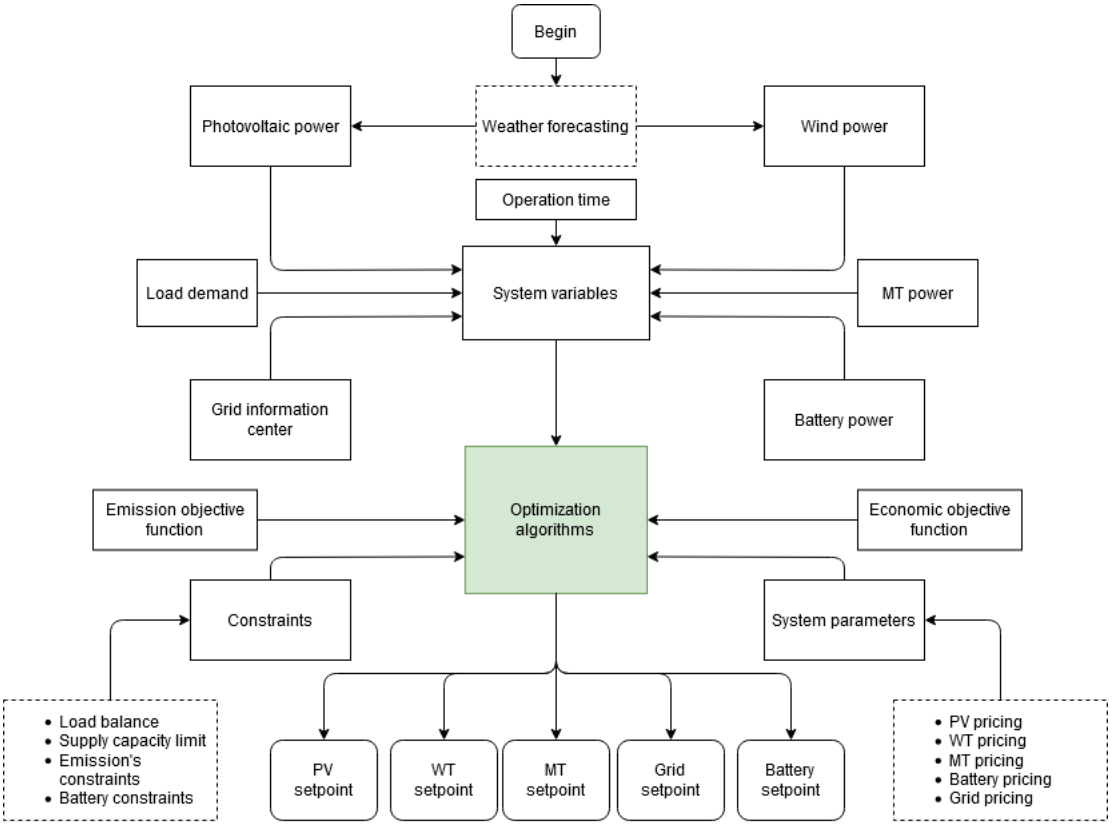

Fig. 1: Microgrid optimization model.

3 Results and discussions

Following the inverse relation obtained between the two parameters (cost and gas emissions) this work treats the problem of microgrids energy management in a multi-objective way considering the simultaneous optimization of the economic and environmental parameters, the optimization algorithm adopted was the Pareto search algorithm, based on the direct multi-search (DMS) principle. In contrast to the uni-objective part characterized by a unique point of convergence representing the global optimum, the multi-objective treatment gave a set of trade-offs between parameters to be optimized as shown in Table 1.

Table 1: The non-dominanted solutions obtained by Pareto-search Algorithm

Scenarios	Total Energy Cost (euro)	Total Emissions (kg)
01	161.0118	1.2795×10^3
02	159.9786	1.2809×10^3
03	159.7697	1.2823×10^3
04	158.5841	1.2872×10^3
05	157.5630	1.2984×10^3
06	156.7201	1.3120×10^3
07	155,8556	1.3239×10^3
08	155.3164	1.3387×10^3
09	154.9797	1.3524×10^3

The non-dominant points are implemented in a Pareto front representing a set of scenarios as shown in Fig 2. In this part, the microgrid manager will be the main decision-maker about which scenario is going to be selected considering both economic and environmental aspects.

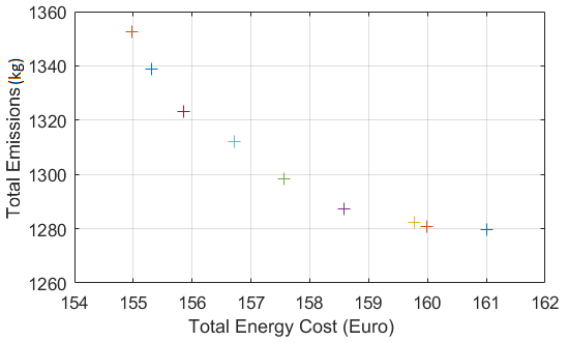

Fig. 2: Pareto front.

4 Conclusion and future works

In this paper, an energy management system based on a multi-objective optimisation approach has been proposed to solve the problem of optimal energy management in microgrids. Both economic and environmental aspects were simultaneously considered and optimised through the Pareto-search Algorithm. The results present a set of non-dominated solutions placed on a Pareto front, allowing the achieving of several microgrid scheduling scenarios. The proposed methodology provides a set of effective Pareto-optimal solutions respecting the technical-economic and environmental considerations of the problem under study and offering to the microgrid operator a variety of options for selecting an appropriate energy allocation scenario based on environmental or economic considerations. The integration of renewable energy sources with information and communication (ICT) technologies into microgrid systems have opened the way to smart cities, however, the intermittent nature of RES leads to moments of temporary failure of energy management systems. Indeed, the integration of forcasting models with a demand management side (DMS) systems will improve the efficiency of the microgrid allowing for more reliable energy management systems. The latter will be a future work proposed as a continuation of this work.

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Monitoring and Optimising of Public Transportation

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Abstract. The smart city topic became a very prominent concept in recent years, especially in the area of public transportation. This work aims to develop a modular GPS sensor based system which can be installed in any transportation vehicle. The module collects GPS location data of the vehicle, user flow and time and sends it through mobile data network to a database in a server. The sent data can be analysed through data mining strategies to decision support in terms of existing routes or add new routes through population flow analysis. The module will be powered by the vehicle via the car auxiliary power outlet. Some data will be available to the users through website and mobile App. In the website the public transportation institution can access to privileged information about it's bus fleet. In the website, the public transportation institution, can access to privileged information about it's bus fleet. In the mobile app, the user, can access the bus arrival time information, if the bus is on time or if it's late.

Keywords: GPS Monitoring · Data Analysis · Optimisation · Modular System.

1 Introduction

Public transport is one of the most used means of transport all over the world, but it aims at some problems that need to be solved, such as: delays, inefficient routes and little contact with its user, thus the need arises to study ways to solve these problems [8].

This project seeks to find a solution to the problems described above. It is composed by the development of a GPS location module, which will send the bus location to a database, as well as the date/time and the number of people getting in and out on the bus in each stop where a laser sensor is used to collect the passengers flow. These data will be later used to predict future passengers flow, reroute recommendations of existing routes and to monitor the bus in case of delays (accidents, weather, traffic, and others). In line with the European "Europe 2030" strategies, we are working to reduce CO2 emissions, increasing the transport is at the expense of our own transport [1].

The paper is organised as follows. The Section 2 presents the developed module to be applied on the bus. The data analysis and some optimisation approaches are presented on Section 3. The SmartMov system is presented on Section 4. Last section is devoted to the conclusions and future work.

2 SmartMov Modular System

The bus modular device aims to monitor the buses, as it will collect the real time location of each bus, the flow of each bus stop and send this data to a database. This

data will be for later use in predictions of flow and real-time recommendations for the end user [4].

The device is organised according to the diagram in Fig. 1.

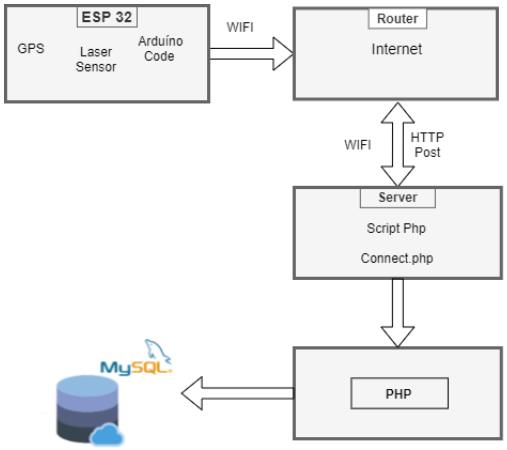

Fig. 1: Diagram of bus modular system.

The system is composed by a Esp32, laser sensor and a GPS where:

- ESP32 will be the controller of the device, it will be responsible for the data collection.
- The GPS will be responsible for locating the device, collecting the latitude and longitude, as well as collecting the date and time.
- The laser sensor will be the responsibility for the people flow value.

All the collected data will be sent using the ESP32. For that task, it will be used it's WIFI stack to connect the router, which will handle the internet access and server connection where the database is located. After being connected to the server, an HTTP post will be required every 25 seconds whereas the HTTP post is the request for the connection to the server. To publish data in the database a phpscript was developed that makes the connection between the ESP32 and all it´s components and the database. After all this steps we will have all the collected data published in the database [7].

A database is a simple repository of information related to all information of the bus routes and collected by the bus module system. In Fig. 2 we can see an example of the tables in the database.

Some information are manually inserted as for example the number of the bus, number of device active, drivers and bus stops. This database will get some information in real time given by the bus module system, named data obtained from GPS and laser sensor. So in real time the database will collect information related to bus position, time and users flows.

All these data will be stored in the database and will later be used for prediction of flow in each bus stop and future changes in the bus routes [6].

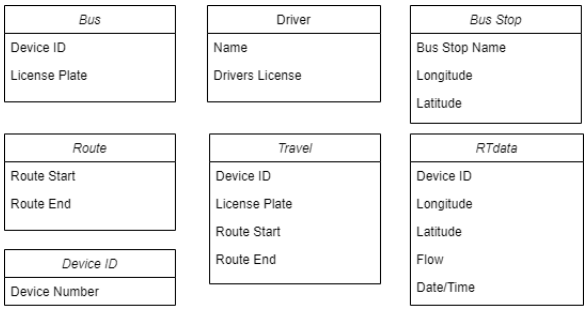

Fig. 2: Example of the database tables.

3 Data Analysis

In this work, the data collected was analysed by *K-means* since it is a classification method [5].

The data gather from the SmartMov Modular System will be collected and stored in a text file. This text file will be exported to Python. It was used the *K-means* method to classify the data associated to the departure time, arrive time, departure location, arrive location and users flow. Using Python, the first step is to run the data-set with a method called *Elbow* [3]. This method will return the ideal number of clusters for the considered data-set. The example in Fig. 4 presents the obtained results of an *Elbow* experiment.

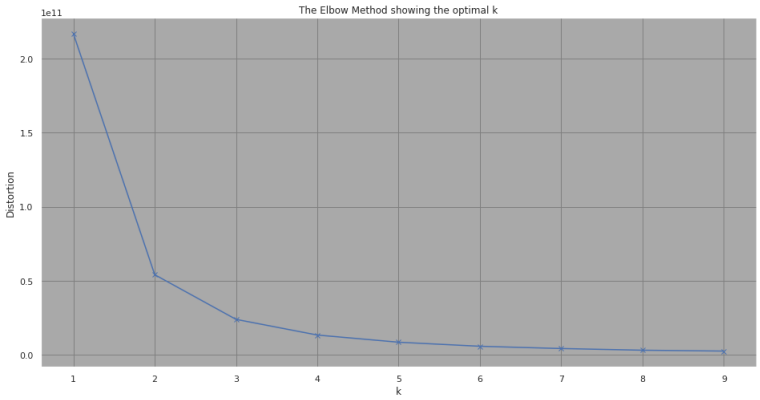

Fig. 3: ***Elbow method when*** $N=4$

Once the results of the previous method are complete, the clustering algorithm *K-means* is launched. This algorithm will calculate the clusters with the number obtained in the *Elbow* method (in this case the N=4).

The goal of *K-means* is quite simple since it groups similar data points and discovers underlying patterns. This method looks for a fixed number of clusters in a data-set [2].

When analysing the output data of *K-means*, it is possible to start to identify patterns. With this information we can start to visualise which stops has a high flow of

passengers and if this flow will affect the bus time arrival in the next stop. We can also spot if a stop has few to none passengers and the bus has to wait till the time to leave that stop.

After a full analysis of this patterns we can start to re-draw a possible new route for individual or collective buses, stretch or shorten the routes.

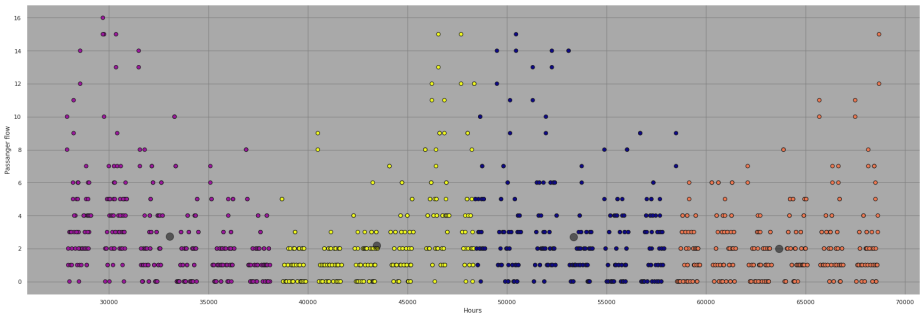

Fig. 4: ***K-means*** **when** N**=4**

4 SmartMov

SmartMov combine the technologies presented in Sections 2 and 3 in order to provide a monitoring and optimisation service for public transportation. With our cost effective FMS solution, companies can set up a professional tracking platform of their own and provide real-time tracking service and fleet management tracking service to their locals residents. SmartMov handles all technological issues, so companies focus strictly on their tracking business to realise rapid and ongoing ROI that includes increased revenue, reduce costs and ability to grow profit.

5 Conclusion and Future Work

This project presents an integrate system combined a bus module system with data analysis to improve the public transportation. The project proposes a new modular system, database and data analysis. The information will be available to the companies with the purpose of monitoring of its fleet and to the public with the purpose of visualising the bus arrival time.

As future work, it is proposed to install and validate the solution in a low density region where there are not any system to support the public transportation decisions.

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Response Surface Method combined with Data Analysis to Optimize Extraction Process Problem

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Abstract. Find and develop an appropriate optimization approach is directly associated with the reduction of the time and labor employed in a given chemical process and could be decisive for quality management. In this context, this work presents an approach to implement the Response Surface Method. This technique combines Response Surface Method with Genetic Algorithm and data mining. The main objective is to develop in MATLAB® a method able to optimize the surface function based on three variables using Hybrid Genetic Algorithms combining with Cluster Analysis to reduce the number of experiments and to find the closest value to the optimum within the established restrictions. The results are in accordance with those reported in a previous study. The proposed method has proven to be a promising alternative strategy since the optimal value was achieved without going through derivability unlike conventional methods, and fewer experiments were required to find the optimal solution in comparison to the previous work using the traditional Response Surface Method.

Keywords: Optimization · Genetic algorithm · Cluster analysis.

1 Introduction

The search and optimization methods have several principles, the most relevant being: the search space, where the possibilities of solving the problem in question are considered; the objective function (or cost function) and the problem coding, that is, a way to evaluate an objective in the search space [1]. Conventional optimization techniques, such as traditional RSM, start from an initial value or vector that is iteratively manipulated through some heuristic or deterministic process directly associated with the problem to be solved [3]. The great difficulty in solving a problem using the stochastic method is the number of possible solutions growing with a factorial speed, making it impossible to list all possible solutions to the problem [4]. Evolutionary computing techniques, as Genetic Algorithm, operate on a population that changes with each iteration. Thus, they can search in different regions of the viable space, allocating an adequate number of members to search in different areas [4].

Thus, considering the importance of predicting the behavior of analytical processes and avoiding costly procedures, this study aims to propose an alternative for optimizing multivariate problems, *e.g.* yield from the extraction of plant matrices. This study presents a comparative analysis between two optimization methodologies (traditional RSM and dynamic RSM), both developed in MATLAB® software (version R2019a 9.6), which aim to maximize the yield of a extraction process.

1.1 Case Study

This work is based on the published experimental data regarding the extraction conditions of male chestnut flowers using heat-assisted extraction [2]. The study parameters: time (t, in min), temperature (T, in °C), solvent (S, organic solvent in %v/v of ethanol) were optimized based on the Circumscribed Central Composite Design (CCCD) and the result was based on the extraction yield (Y, expressed as a percentage of dry extract). The CCCD design selected by the authors is based on a cube circumscribed to a sphere in which the vertices are at an α distance from the center and have 5 levels for each factor (t, T, and S). In this case, the α values vary between -1.68 and 1.68, and correspond to each factor level.

2 Dynamic Response Surface Method

For the newly proposed optimization method, briefly described in the flowchart shown in Fig. 1, the structure of the design of the experience was maintained and the imposed constraints on the responses and variables were adopted for dynamic RSM to elude awkward solutions.

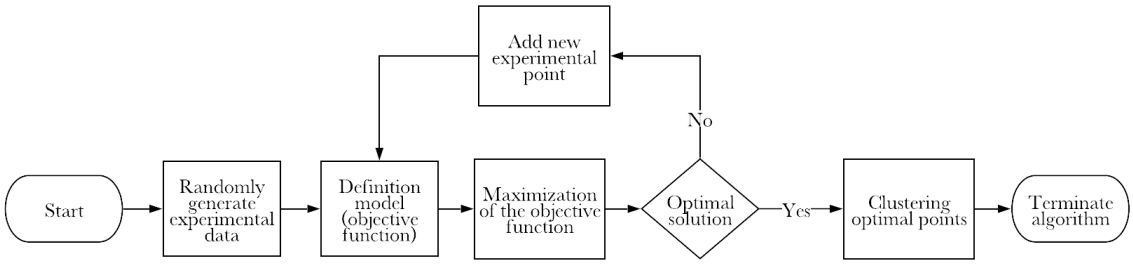


Fig. 1: Flowchart of dynamic RSM integrating Genetic Algorithm and cluster analysis to the process.

The algorithm was developed in MATLAB® software and starts by generating a set of 15 random combinations between the levels of combinatorial analysis. From this initial experimental data, a multivariate regression model is calculated, being this model the objective function of the problem. The Genetic Algorithm was used to solve the optimization problem. The optimal combination is identified and it is used to define the objective function. The process stops when no new optimal solution is identified

For the implementation of dynamic RSM in this case study, one hundred tests were performed to assess the effectiveness of the method. Considering the stochastic nature of the problem, cluster analysis is used to evaluate the outputs of the tests and identify the best candidate ideal solution. To handle the variability of the optimal solution achieved, the bootstrap method is used to estimate the confidence interval at 95%, by re-sampling data (1000 re-samples).

3 Numerical Results

According to the previous work using traditional RSM, the optimal conditions for maximum yield were: 120.0 min, 85.0 °C, and 44.5% of ethanol in the solvent, producing 48.87% of dry extract [2]. Using dynamic RSM, the estimated optimal conditions for the same response variable were: 118.5 min, 84.1 °C, and 46.1% of ethanol in the solvent, producing 45.87% of dry extract. In this case, the obtained optimal conditions for time and temperature were in accordance with approximately 80% of the tests.

The clustering analysis for each response variable was performed considering the means and the medoids for the output population (optimal responses from all tests) and the *bootstrap* analysis enables to make the inference concerning the results achieved, as shown in Figs. 2 and 3.

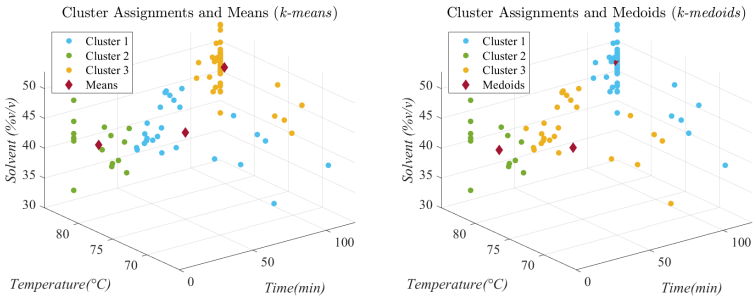


Fig. 2: Clustering analysis of the outputs from yield optimization using dynamic RSM: *k-means* and *k-medoids*, from left to right.

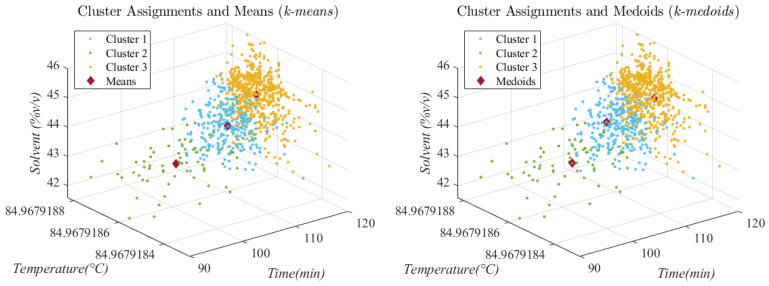
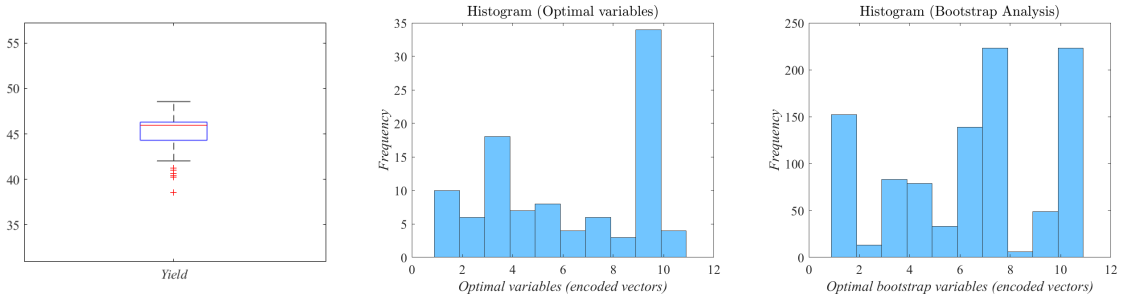


Fig. 3: Clustering analysis of the bootstrap points from yield optimization using dynamic RSM: *k-means* and *k-medoids*, from left to right.

The box plot corresponding to the group of optimal responses (yield) from dynamic RSM shows that the variance within each group is small, given that the difference between the set of responses is narrow. The histograms concerning the set of dynamic RSM responses and the bootstrap distribution of the mean (1000 re-samples) are shown in Fig. 4.



(a) Box plot of the outputs.

(b) Histogram of the outputs.

(c) Histogram of the bootstrap means.

Fig. 4: Box plot and histograms for the outputs of the testes using dynamic RSM.

The results obtained in this work are satisfactory, since the dynamic RSM returned values sufficiently close to those obtained using the traditional RSM [2]. Dynamic RSM took from 15 to 18 experimental points to find the optimal coordinates while some authors use the traditional RSM approach containing 20 combinations, including repetitions at the centroid. In addition to cluster analysis, bootstrapping was also applied, in which the sampling distribution of the statistic of interest is simulated through the use of several re-samplings with replacement of the original sample, enabling statistical inference. Bootstrapping was used to calculate confidence intervals to obtain unbiased estimates of the proposed method. In this case, the confidence interval was calculated at the 95% level (two-tailed), analogous to the previous study [2]. It was observed that the Dynamic RSM approach also allows the construction of confidence intervals with a smaller margin of error than the Traditional RSM approach, leading to a more precise definition of the optimal conditions for the experiment.

4 Conclusion and Future Work

For the presented case study, applying dynamic RSM using Genetic Algorithm coupled with clustering analysis returned positive results, in accordance with previous published data [2]. Both methods proved to be applicable to the resolution of this particular case regarding the optimization of the extraction of target compounds from plant matrices. However, although the dynamic RSM method proposes an alternative and different approach, the number of experimental points is slightly lower in comparison to the traditional method. Further studies are suggested to improve the algorithm and evaluate its performance using other case studies. In conclusion, dynamic RSM can be used as an alternative to traditional optimization methods, being effective and robust in estimating optimal conditions.

Acknowledgments

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Novel SOC Monitoring Approach for Lithium Batteries

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Abstract. The key element in storage based systems remains the ability to monitor, control and optimise the performance of one or more modules of these batteries, the type of device performing this task is often referred to as a Battery Management System (BMS). A BMS is a basical units of electrical energy storage systems, a variety of already developed algorithms can be applied to define the main states of the battery, among others: state of charge (SOC), state of health (SOH) and state of functions (SOF) that allow real-time management of the batteries. All research in the field of Extended Kalman Filter (EKF) based BMS is based on bench-scale experiments using powerful softwares, such as MATLAB, for data processing and controllers such as dSPACE. So far, the constraint of computational power limitation is not really addressed in the majority of scientific papers dealing with this subject. This paper proposes an approach to implement an extended Kalman filter linked to a Coulomb counting method, this method called DCC-EKF will allow a better quality monitoring of the battery.

Keywords: Embedded System · Battery Management System · Extended Kalman Filter · Coulomb Counting.

1 Introduction

For battery-based systems, whether a hybrid vehicle, a solar powered device, or any other everyday electrical device (Robots, smartphone, laptop...), the battery is usually the only source of power they can access and rely on. As the importance of energy storage has continued to grow in recent years, researchers around the world have been developing more powerful and efficient batteries, both in terms of energy density and resistance. But developing the most powerful battery without optimising its management remains an act of little value, hence the power management of these batteries is so crucial and must be done properly. A good BMS is one that accurately estimates the SOC and SOH, basic approaches such as Open Circuit Voltage (OCV) and Coulomb Counting (CC) techniques, or slightly more complicated ones such as sliding mode [1], artificial intelligence [2] and Kalman filtering [3], are then used to try to estimate or predict the actual SOC of the battery.

As no specific accuracy requirement are defined, basic approaches are mostly used in smartphones and computers, they certainly use less time to calculate the state of charge, with a higher performance, but they do not produce an accurate calculation and generally give a misleading representation of it and lead to errors accumulation overtime. On the other hand, the complex methods, allow indeed to limit the error and the impact of uncertainties on the final result, but requires a computational power that is generally

accomplished by the use of powerful controllers such as dSPACE. All research in the field of EKF-based BMS is based on bench-scale experiments using powerful software, such as MATLAB, for data processing. So far, the constraint of computational power limitation is not really addressed in the majority of scientific papers dealing with this subject.

This paper validates the possibility of applying an extended Kalman filter in an ATMEGA328P. This approach, called DCC-EKF, consists of performing an SOC prediction with an EKF function, and then sending the result to a Coulomb counting function for monitoring. The approach is implemented in a Battery Managment System designed from scratch.

2 Proposed BMS

For the BMS to provide optimal monitoring, it must operate in a noisy environment, it must be able to electrically disconnect the battery at any time, it must have the ability to monitor the state of each cell of the battery independently of the others, it must charge and discharge all the cells with the same rate, and in addition it must keep a constant monitoring on various parameters that can greatly influence the battery, such as cell temperature, cell terminal voltage and cell current [4, 5]. The general representation of the BMS is shown in Figure 1.

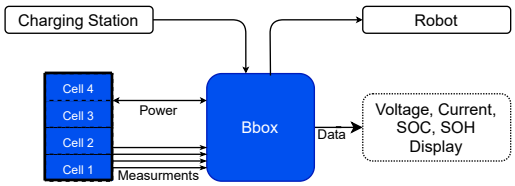

Fig. 1: General Representation of the *"Bbox"* Battery Managment System

The battery states are determined for each cell independently of the others by a specific microcontroller assigned to it, and works with the principle of Master/Slave communication by the means of I2C [6]. One microcontroller defined as a Master regroup the information and characteristic gathered from each other slaves microcontroller, analyses them and takes the main precautions to avoid any deep charge or discharge of the batteries, In order to keep a low sampling time, one slave microcontroller is assigned to two batteries, reaching a sampling time of the implemented algorithm of 0.085 seconds, all the three microcontrollers used are ATMEL's ATMEGA328P.

The master microcontroller is also connected to push buttons and an OLED screen to facilitate communication with the user. Power is supplied directly from the batteries, the voltage is stabilised and regulated for the BMS electronics by an step-down voltage regulator. The current flowing in and out the battery is measured with the use of an ACS-712 current measurment device. The voltage offered to the robot by the Bbox varies between 15 V and 11 V , no regulation is made keeping the regulation of the external voltage to the future users of the device.

3 Algorithm Description

The algorithm of this system consists mainly of two modes, the *initialisation mode* and the *on-mode*, both of which are highly dependent on each other. The use of an *initialisation mode* may seem strange at first sight for this type of product, but it is important to remember that the characteristics between cells are not uniform, neglecting this aspect can significantly reduce accuracy. *The initialisation mode* is responsible for the initialization of the battery capacity, in addition to activate or deactivate some features. As for the *On-mode*, the device shall begin the prediction of the actual SOC value for each cell using an EKF function described in Figure 2, and prohibits the passage of current to the robot for a period of approximately 3 minutes, the BMS electronics are still powered with a 70 mA current.

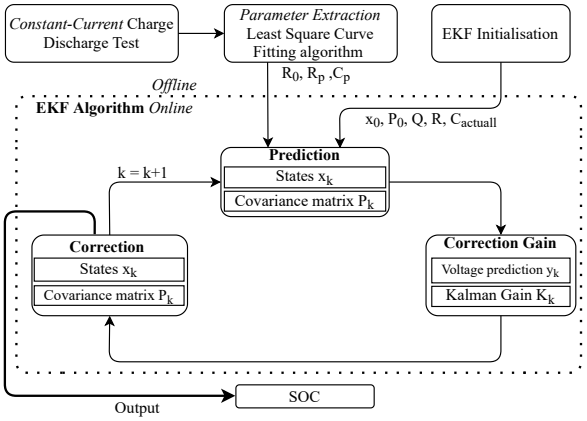

Fig. 2: Flow chart of the EKF function

Then, the predicted SOC is forwarded to the Coulomb counting function, which monitors the SOC using the following equation:

$$SOC(t_n) = SOC(t_{n-1}) + \frac{n_f}{C_{actual}} \int_{t_n}^{t_{n-1}} I \cdot dt \tag{1}$$

4 Results and Discussions

The BMS designed from scratch, implementing the new approach, can measure voltage with an accuracy of 100 mV and current with an accuracy of 40 mA and has an average energy efficiency of 94.38 %, and a total cost for one single prototype estimated at 32,21 €. The protection of the cell is provided by a S8254-A cell protection chip. The designed PCB is shown in Figure 3.

A test of the proposed EKF function was performed for correct and incorrect parameters in order to know its exact behaviour. For correct parameters (Figure 4), the EKF algorithm converges quickly and accurately to the SOC, an average of 3.81 % was recorded, in addition, this estimator is robust and resistant to external noise, a very important aspect for a BMS.

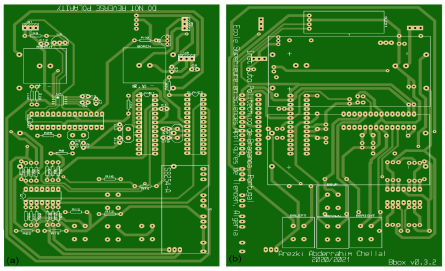

Fig. 3: Prototype printed circuit board. (a) componants view. (b) top view.

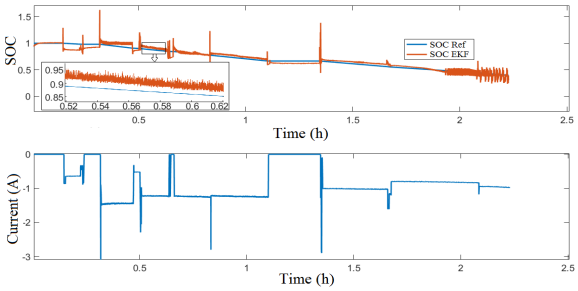

Fig. 4: Estimated and reference SOC comparison with the measured current

But for inaccurate parameters initialization, the algorithm converges to an incorrect value, the error increases as the difference between the actual value and the value of the implemented parameter increases. When the current stopped, the EKF converged rapidly, reaching a preliminary error of 10 % within a few sampling times, and then slowly converged to the reference SOC, after about 3 minutes it reached an error of less than 5 %. Figure 5 shows the results of wrong parametrization.

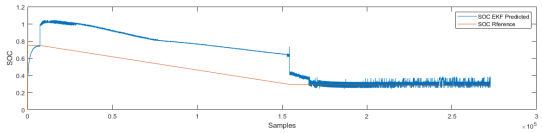

Fig. 5: Results of the EKF prediction with wrong parameters

5 Conclusion & Future Work

This study confirmed the possibility of implementing an EKF-based algorithm for SOC determination in an 8-bit microcontroller, taking advantage of its excellent behavior when the batteries are resting. This algorithm is implemented in a BMS designed meeting most of the constraints defined for such a device. The device is capable of reaching an accuracy of 5 %. The future development of this project will improve the prediction and introduction of an SOH monitoring, in addition to improving its energy efficiency and reducing its size.

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   Oct 2017

Functional Electrical Stimulation System for a Wearable-based Biostimulation

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Abstract. The objective of this paper is to describe the methodology and preliminary results of the development of an electrical stimulation system, for a wearable device aiming the biostimulation. The paper describes the project environment of this work, the function and importance of the functional electrical stimulation, the current development of the system and presents the preliminary results with further expectations.

Keywords: Functional Electrical Stimulation · Wearable · Stimulation circuit.

1 Introduction

The Vastus Medialis muscle is a part of the quadriceps muscle group [3] [6]. The weakness in this muscle is one of the main factors that could provoke some patellar illness [5] [2]. This weakness may be caused by muscle atrophies, and in order to prevent those kinds of situations, physical exercise is essential. However, in a few cases, only the exercises may not be enough to provide the strength needed to properly treat them. Seen this, the Functional Electrical Stimulation (FES) become a good option in the reinforcement of the muscle, proving to be one of the best solutions to help on the treatment.

Between the existing solutions on the market, most of them have clear disadvantages compared with the proposed solution. The commercial solutions can provide the waveform required for the treatment in a "closed" matter, by applying a signal with constant parameters defined by levels of operation. In other words, the systems have a routine with preprogrammed stimulation patterns, which implements a constant value for the impulse parameters based on a lookup table [1]. Furthermore, those equipment's are bulky or even static, which restricts the movement capacity of the patients.

The main challenges of this project are to develop a system with an open architecture to apply a required pulse for which situation, and make it small enough to fit in a wearable device with the proper autonomy and power to fulfill the required parameters for the treatment.

Having this in mind, the objective of this work is to develop a system capable of receiving an impulse signal determined by the control system according to the therapy procedure and apply this impulse without any kind of harm to the patient using the electrodes embedded in a wearable device. This paper describes the ongoing work regarding the development of an electrical stimulation system to be incorporated in such wearable-based biostimulation system, and analyses the preliminary results.

The rest of the paper is organized as follows. Section 2 overviews the architecture for the wearable-based integrated biostimulation system, particularly including the signal acquisition and conditioning system and the functional electrical stimulation. Section 3 presents the functional electrical stimulation system, and Section 4 presents the preliminary results. Finally, Section 5 rounds up the paper with the conclusions and points out the future work.

2 Wearable-based Integrated Biostimulation System

NanoStim is a development project of a wearable device to assist in the treatment of knee pathology's caused by a deficiency on the vastus medialis muscle. The project is subdivided into three parts, those are acquisition, conditioning system, and electrical stimulation.

The first part aims to acquire the Electromyography (EMG) signal generated by the muscle, the second one analyzes the data using a machine learning system, and answer with a signal to the third part, who generates an electrical stimulus to assist the muscle activities. The basic architecture can be observed in Fig. 1.

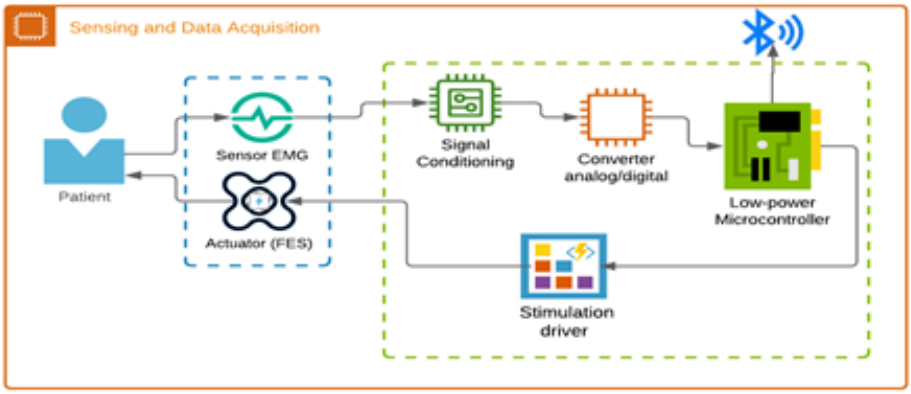

Fig. 1: Architecture of the acquisition, signal processing and electrostimulation system.

3 FES System Architecture

Seen this, the goal of this part of the project is to develop a system capable of receiving a command signal by wireless communication and generate an electrical stimulus. For this, is necessary to comprehend the concept of electrical stimulation, understand the functioning of the electrodes and their connections, and develop a circuit capable of delivering the appropriate current signal.

3.1 Functional Electrical Stimulation

Functional electrical stimulation generates muscle contractions by artificially inducing a current in specific motor neurons. Those electrical currents are delivered in pulses

using electrodes. These electrodes can be wet or dry and can be placed on the skin surface, within a muscle, on the surface of the muscle, or around the muscle nerve [4].

The tension produced on the electrically stimulated muscle depends on the intensity and frequency of the stimulation. This intensity is determined by a function of the charge transferred to the muscle, which depends on the amplitude, duration, frequency ,and shape of the pulse [4]. A typical electrical stimulation pulse is shown in figure 2.

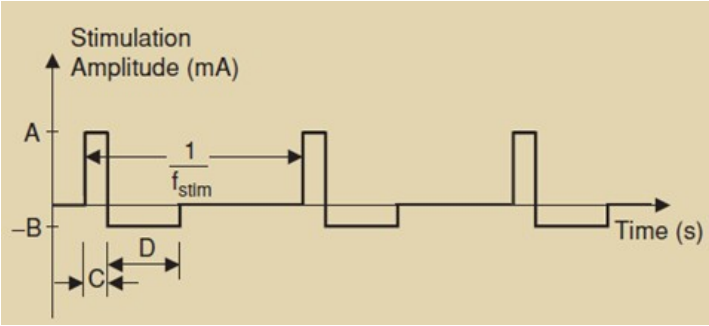

Fig. 2: Electrical stimulation pulse. A typical waveform, a square-wave pulse train used for transcutaneous FES [4].

3.2 The Stimulation Circuit

The stimulation circuit needs to receive a command and generates a current pulse with the pre-determined parameters. So the circuit is divided into two parts, software ,and hardware.

The preliminary hardware circuit is composed of an integrated circuit (IC) that sends impulses to a circuit composed of a pair of transistors and discreet components. Those impulses will be translated to the appropriate waveform by the components, and the output voltage has to be amplified to achieve the necessary voltage to stimulate the muscles.

To fulfill the amplification of the output voltage was studied two possibilities, the use of a low power elevator transformer and a DC/DC step-up converter. During the test was verified that the required voltage for stimulation was around 45 to 48 volts, so the step-up converter was discarded once it didn't provide the required output value. Seen this, the transformer is the best alternative.

The software part is the one that receives the command and provides the impulses with the specific characteristics for the stimulation signal. So it must be configured to produce the impulse with the values of the amplitude, frequency, duration ,and shape acquired by the IC.

It is important to consider that the circuit must have an open architecture and low power consumption once will be integrating into a wearable device so it can not be bulky, and needs to adapt to distinguished stimulation patterns.

4 Preliminary Results

The circuit was tested using pre-determined values, once the software part is not ready to receive the acquisition parameters. In this way, the circuit receives two impulses of 100μ seconds, one after the other, every 20m seconds, and the amplitude of the pulses was regulated by an external power source at 3V. The period and waveform of the signal can be observed in figures 3 and 4.

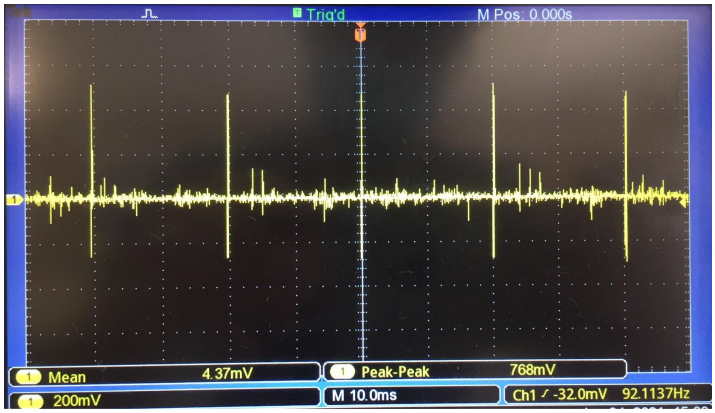

Fig. 3: Impulse period

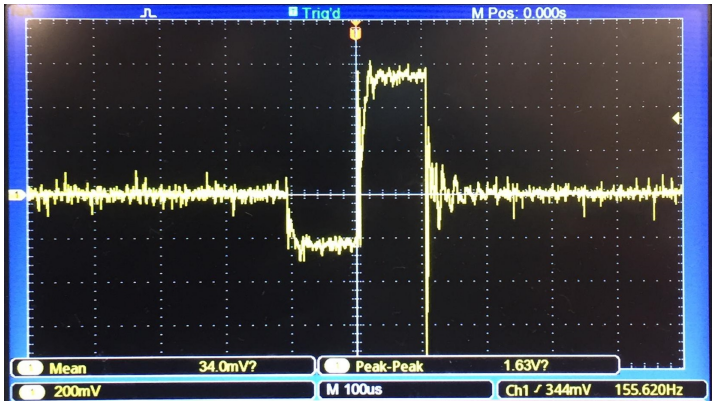

Fig. 4: Wave form

Figure 3 shows the impulses received by the circuit every 20m seconds, and figure 4 presents the waveform obtained with the determined value of 100μ seconds for the pulse duration.

5 Conclusions

The preliminary results show that the designed circuit is able to generate the estimated stimulation pattern, within the proposed period determined by the control module. The obtained waveform and period of the signal constitute the base components to set up the proper output signal to fulfill the stimulation.

However, the output value is inferior to the one needed to fulfill the stimulation, which requires further development to reach the appropriate output voltage for the system. Additionally, future work will be devoted to improving the quality of the waveform, and integrating the FES system with the rest of the data acquisition and processing system.

Acknowledgment

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DNS firewall based on Machine Learning: Proposal, Methodology and Preliminary Results

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Abstract. In this paper we present a data analytic process that involves the creation of a Domain Name Service (DNS) dataset to be trained by machine learning algorithms in order to detect malicious DNS domains on the fly. The dataset is based on real DNS logs and it was enriched using Open Source Intelligence (OSINT) sources. The exploratory analysis and data preparations steps were carried and the final dataset will be submitted to different Machine Learning (ML) algorithms. Some preliminary results reveals the accuracy and time required to classify if a domain request is malicious or not.

Keywords: Cybersecurity · DNS · Firewall · Machine Learning.

1 Introduction

The DNS is a fundamental service to the functioning of the Internet. As the Internet grows, so does the number of DNS domains. According to the report provided by Verisign [7], the second quarter of 2020 closed with 370.1 million domain name registrations across all Top Level Domain (TLD). An increase of 0.9 percent when compared to the first quarter of 2020 and a growth of 4.3 percent, year over year. Unfortunately, this growth has a less positive side. In [6] it is said that 70% of newly 200,000 registered domains every day are malicious or suspicious.

In this paper we present a proposal to build a DNS firewall based-on machine learning. The proposal includes the creation of a dataset from scratch and the posterior data preparation and analysis in order to assess its accuracy. The dataset contains 90000 different domains classified *a priori* as malicious or benign. From the DNS query were derived 34 different features. The missing values, outlier analysis and data distribution were analyzed and the resulting dataset submitted to different machine learning supervised classification algorithms.

The rest of the paper is organized as follows: Section 2 presents the related work; the proposal and methodology is presented in section 3; the data analytics process and the preliminary results are presented in section 4; section 5 concludes the paper.

2 Related Work

Several studies investigate the security of DNS systems and how to improve the detection of cyber threats using ML algorithms. In [2] authors used nine features of botnet domain querying and a popular classifier algorithm to pick the malicious domains out

of DNS traffic. The results obtained using the Random Forest classifier algorithm reach the 99.38%, a false positive rate of 0.28% and a false negative rate of 1.86%. A more recent study presented in [3] combines blocklists / allowlists with a ML approach on DNS traffic.A deep neural architecture model was trained using passive DNS database. This study was able to detect if a domain is benign, malign or a sinkhole with 95% of accuracy on malicious and a false positive rate of 1:1000. The study also uses different algorithms and presents a comparison table for each one. To avoid the take-down of botnets by the law enforcement authorities, malicious authors make use of Domain Generation Algorithm (DGA). This technique generates random domain names that change over time, making the sinkhole process and botnet take down difficult. In [4], a ML model is proposed to identify DGA domain names and improve the security of DNS firewall solutions.

The use of DNS Response Policy Zone (RPZ) to block malicious domains is still a useful approach [8]. Using ML algorithms, such the logistic regression classification algorithm, to actively identify possible threats at DNS level as presented in [5] combined with a DNS RPZ approach can be valuable and improve the detection of malicious domains.

3 Proposal and Methodology

Considering the number of newly domains and the growing number of domains associated with malicious activities, the development of a DNS firewall is of utmost importance. It is meant to protect users from accessing malicious domains, preventing the installation of malware, the communication with command and control servers, the access to phishing websites and data exfiltration.

A system as we propose can be used to complement the DNS firewall systems based on DNS block and allow lists with algorithms capable of verifying if a domain is malicious or not. In the first phase, a dataset was created using non-malicious and malicious domains. The second phase focus on the preliminary results achieved by different ML applied on the dataset. This phase is still in progress, so some results could improve or change over time as we study and fine tune the parameters and hyper parameter for each algorithm.

4 Data Analytics

In this section we present the data analysis process. This process start with the creation of the dataset, the posterior data preparation and then the data analysis phase that allows us to obtain the first classification results regarding if a given domain is malicious or not.

4.1 Creating the dataset

To create the dataset we started from lists of already classified malicious and non-malicious domains (data sources). All started with a simple domain name and for each domain a DNS query was performed. The results were logged and then processed.

Several Python modules were created to extract the different features from the domain name. So, using the domain name as input, 34 features (described in Table 1) were obtained.

Table 1: Dataset features with description, data types and default value

Feature	Description	Data Type					Default Value
		Text	Boolean	Integer	Decimal	Enumerate	
Domain	Baseline DNS used to enrich data (derive features)	X					N/A
DNSRecordType	DNS record type queried	X					N/A
MXDnsResponse	The response from a DNS request for the record type MX		X				False
TXTDnsResponse	The response from a DNS request for the record type TXT		X				False
HasSPFInfo	If the DNS response has Sender Policy Framework attribute		X				False
HasDkimInfo	If the DNS response has Domain Keys Identified Email attribute		X				False
HasDmarcInfo	If the DNS response has Domain-Based Message Authentication		X				False
Internet Protocol (IP)	The IP for the domain	X					null
DomainInAlexaDB	If the domain it's registered in the Alexa DB		X				False
CommonPorts	If the domain it's available for common ports (80, 443, 21, 22, 23, 25, 53, 110, 143, 161, 445, 465, 587, 993, 995, 3306, 3389, 7547, 8080, 8888)		X				False
CountryCode	The country code associated with the IP of the domain	X					null
RegisteredCountryCode	The country code defined in the domain registration process (WHOIS)	X					null
CreationDate	The creation date of the domain (WHOIS)					X	0
LastUpdateDate	The last update date of the domain (WHOIS)					X	0
ASN	The Autonomous System Number for the domain			X			-1
HttpResponseCode	The HTTP/HTTPS response code for the domain					X	0
RegisteredOrg	The organization name associated with the domain (WHOIS)	X					null
SubdomainNumber	The number of sub-domains for the domain			X			0
Entropy	The Shannon Entropy of the domain name			X			0
EntropyOfSubDomains	The mean value of the entropy for the sub-domains			X			0
StrangeCharacters	The number of characters different from [a-zA-Z] and considering the existence maximum of two numeric integer values			X			0
TLD	The Top Level Domain for the domain	X					null
IpReputation	The result of the blocklisted search for the IP		X				False
DomainReputation	The result of the blocklisted search for the domain		X				False
ConsoantRatio	The ratio of consonant characters in the domain				X		0
NumericRatio	The ratio of numeric characters in the domain				X		0
SpecialCharRatio	The ratio of special characters in the domain				X		0
VowelRatio	The ratio of vowel characters in the domain				X		0
ConsoantSequence	The maximum number of consecutive consonants in the domain			X			0
VowelSequence	The maximum number of consecutive vowels in the domain			X			0
NumericSequence	The maximum number of consecutive numerics in the domain			X			0
SpecialCharSequence	The maximum number of consecutive special characters in the domain			X			0
DomainLength	The length of the domain			X			N/A
Class	The class of the domain (malicious = 0 and non-malicious = 1)			X			N/A

Features like the domain name entropy, number of strange characters and domain name length were obtained directly from the domain name. Other features like, domain name creation date, IP, open ports, geolocation were obtained from data enrichment processes (e.g. OSINT). The class was determined considering the data source (malicious DNS log files and non-malicious DNS log files). The dataset consists of data from approximately 90000 domain names and it is balanced between 50% non-malicious and 50% of malicious domain names.

4.2 Data preparation, Data analysis and Preliminary results

On data preparation the Domain and Ip columns were anonymized on the dataset. For the text type columns we use the Label Encoder from SkLearn framework [1] with a value between 0 and $n\_classes - 1$. The boolean type was transformed to integers (0 and 1). For all integers it was used the min-max normalization exporting all the values to a range between 0 and 1. The algorithms used to the preliminary evaluation

were: Support-Vector Machine (SVM), Logistic Regression (LR), Linear Discriminant Analysis (LDA), K-Nearest Neighbors (KNN), Decision Tree (CART) and Naive Bayes (NB). Two different algorithms were used to select the most significant features for the analysis: (1) Extra Trees algorithm and (2) Univariate feature selection. In both cases, the dataset was split between training and testing groups using 10-fold cross validation. For the number of folds (10), the analysis of the state of the art was taken into account. The results are presented in Table 2.

Table 2: Table with Machine Learning results using Extra Trees

Algorithm	**Test Mode**	**Feature selection (1)**	**Accuracy**	**Time (sec)**	**Feature selection (2)**	**Accuracy**	**Time (sec)**
SVM	10-fold-cross-validation	9 features	0.912456	499.165	9 features	0.919911	534.308
LR	10-fold-cross-validation	9 features	0.916622	5.2711	9 features	0.916711	4.03559
LDA	10-fold-cross-validation	9 features	0.908822	1.19985	9 features	0.906233	1.18046
KNN	10-fold-cross-validation	9 features	0.949789	47.456	9 features	0.947333	79.0447
CART	10-fold-cross-validation	9 features	0.947833	0.950081	9 features	0.956022	0.774204
NB	10-fold-cross-validation	9 features	0.903156	0.46814	9 features	0.908289	0.359953

The results obtained so far are encouraging. These results show that the algorithms are able to distinguish between benign and malicious domains with accuracy rates between 90% and 95%. Considering that the time to detect malicious domains is very important, the analysis presented also considers the time, in seconds, that each algorithm took to make the decision.

5 Conclusion

In this paper we presented a proposal for the creation of a machine learning-based DNS firewall solution. This work is an important contribution to the improvement of the DNS firewall legacy systems based on block/allow lists depending on previous known malicious domains. It is possible to apply the dataset on ML algorithms and, depending on the accuracy and execution time, select the best approach and implement a real-time DNS firewall alert system in order to increase the security of the internet usage. The preliminary results on this dataset and the correlation of various ML algorithms allow us to have a general idea of the most accurate, precise and timeless algorithm to study in advance. Since the results are mainly above 90% we expected that with the application of techniques on the ML algorithms, such hyper parameter tuning, it will be possible to build a significant model to be applied in a real scenario. The public availability of the created dataset to the scientific community is also important, since it allows the methodology to be adopted for the implementation of a DNS firewall that will take advantage of Supervised Classification Machine Learning Algorithms to detect if a given domain is potentially malicious or not.

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Identification and Characterization of Improvement Opportunities in Industrial Processes

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Abstract. Flexibility in responding to demand has become a major challenge for industries today. To achieve customer expectations, organizations must be flexible enough to offer a wide range of products and services that are available at any time and with the quality expected by customers. Digitization and Industry 4.0 have a strong impact on today's production environment. Established lean production methods are part of this flexibilization process and can be improved through new technologies. Any digitization must deal with waste and reduce it more effectively than a classic lean approach could. When compared to conventional automation, lean automation spaces are smaller, system prices are cheaper, inventory and energy use are lower. The system designer and operator, however, must have higher skills and knowledge. The integration of innovative automation technology along with lean production is an up-to-date and promising topic as industry 4.0 will not solve the problems of poorly organized and managed manufacturing systems. Furthermore, its tools must be applied to lean activities that are already successful even before automation.

Keywords: Industry 4.0. · Lean Manufacturing · Continuous Improvement · Industrial Processes.

1 Introduction and framework of the theme

The world social and economic situation is in constant change, creating in companies the need to adapt to remain competitive in the field in which they operate. In addition, the world is increasingly competitive, looking for good practices, efficiency and solutions that optimize production and distribution, so it is important to unite the practical universe with the academic world to enable the discovery of new paths for new solutions, solutions that are leaner in the area of waste, but highly effective.

Therefore, this initial research project aims to show how the combination of the application of Lean Manufacturing tools with Industry 4.0 is possible and facilitating inside organizations, with an emphasis on Kanban Pull System and visual management.

Lean Manufacturing is a tool used to carry out the dynamic process and seeks the new solutions mentioned above through continuous improvement, so that it works, it depends on the understanding and involvement of all the company's employees. It gives manufacturers a competitive advantage, reducing costs and improving productivity and quality. It improves production, processing, cycle, and setup time, as well as decreasing inventory, defects, and waste [2].

2 Principles of Lean Manufacturing (LM)

There is a sequence of five concepts that companies can adhere to improve their processes, with the objective of producing high quality products, reducing production costs and satisfying the needs of their customers. The five concepts are:

- Specify Value: the product's value must always be defined by the end customer, the company must meet these requirements only with tasks that add value to the final product, without waste.
- Identify the Value Stream: identify all operations that add value, from planning to marketing a particular product.
- Flow: Flow optimization is the fluid processing of a service/product, it only has activities that add value and minimize waste.
- Pull: a product must only be produced after a customer order. With this request, the production requirement for a given product is generated, in a given quantity and on a given delivery date.
- Perfection: eliminating waste and creating value must be continually pursued. This principle comes from the Kaizen philosophy that seeks perfection through continuous improvement [14].

3 Kanban Pull System and Visual Management

The pull production system is driven by the customer, that is, by the output of the production process and is integrated into the Toyota Production System philosophy. Its operation consists of a flow of information parallel to the flow of materials, but in the opposite direction, in the form of some kind of visual symbol, called Kanban [5].

The main objectives are: to minimize the inventory and fluctuation of work-in-process, in order to simplify its control; reduce production lead time; raise the level of factory control through decentralization: give area operators and supervisors a role of production and inventory control; react more quickly to changing demand and reduce defects [9]. Employees do not need to analyze whether or not there is a material shortage, with Kanban identification cards, stock levels are visible, as well as manufacturing orders to be processed.

The cards can be physical or virtual, usually in green, yellow and red, indicating if it is not necessary to produce, if the production is flowing well, or if it is necessary to produce more to meet the next process, respectively. As a rule, production must necessarily be started for cards that reach the yellow band. [3].

Information boards containing standard work methods, objectives, performance indicators, along with communication boards, are tools that facilitate working on the shop floor and increase employee satisfaction [13]. Physical Kanban cards are widely used in industries, however, the idea is to automate the system so that better results are achieved, visual management is very important in this scenario, as it facilitates the visualization and understanding of the system for employees.

In the kanban board, analogous to the card system, magnets and plastic chips are used as a sign. Contains all production processes, and as soon as the product is moved,

the flag is moved on the frame according to that move. When this product is consumed, the signal representing the product is moved to the Kanban board production queue [8].

With the light indication, the operator activates a light command at his workstation every time he consumes a product. This signal is transmitted to the production cell of that item, where a light will be turned on for each unit to be produced. The worker at the supplying station triggers a command for each unit he produces, which causes the lights to go out [10].

4 Industry 4.0 (I4.0)

The industrial sector has always been extremely important for the economic development of each country and the partnerships between them. Since the end of the 17th century, the industry has undergone transformations that revolutionized the way in which products are manufactured and brought several benefits, mainly the increase in productivity [11].

A study released by the Technische Universität Dortmund [6] states that there are some important components for the formation of Industry 4.0, they are:

- Cyber-Physical Systems (CPS): intelligent machines, products and devices are used that exchange information autonomously, working in collaboration with the physical world around them [4]. This information allows workstations to identify which manufacturing steps must be performed for each product and which ones adapt to perform a specific task [7].
- Internet of Things (IoT): is the network of physical objects, systems, platforms and applications with embedded technology to communicate and/or interact with internal and external environments [12]. RFID can be used as an example in the use of IoT, improving the production flow.
- Internet of Services (IoS): Similar to IoT, it uses services rather than physical entities. "Through IoS, internal and Inter-organizational services are offered over the internet and can be used by all participants in the value chain" [1].
- Smart Factories (SF): new industrial structures, with intelligent devices, connected to a network, where products and production systems have communication capability [11]. In smart factories, physical prototypes will become less important, simulations will promote real-time data to replicate the physical world in a virtual model [1].
- Vertical integration (VI) network of intelligent production systems: uses CPS to react quickly to changes in the level of demand, inventory and possible failure. All processing steps, including discrepancies, are automatically recorded.
- Horizontal integration (HI) of the value chain in a network: these are real-time optimized networks that allow for integrated transparency, offer a high level of flexibility to respond more quickly to non-compliances and allow for better global optimization.

5 Lean Automation and Applications

Lean Manufacturing and Industry 4.0 are concepts with different origins and moments of appearance, but they seek the same goals: reduce waste and improve companies'

production. However, they are executed in different ways, LM through waste reduction and I4.0 through exploring new technologies powered by the IoT.

At Table1 is shown which I4.0 tools can be inserted into the LM tools resulting in Lean Automation.

Table 1: Lean Automation.

	RFID	CPS	IoT	Cloud	Big Data	Augmented Reality	SF	H&V I
Continuous Flow	X	X	X	X	X		X	X
Just in Time	X		X	X	X			
Kanban	X			X	X			
Pull Systems	X			X	X			
Total Preventive Maintenance and Predictive Maintenance			X	X	X	X		
Work in Process			X	X	X	X		

All of the lean production techniques presented here are aided by cloud and big data tools to further improve results. This shows the utility and flexibility of Lean and Industry 4.0 integration. RFID, an improved version of the bar code, is also of great help, it can assist in logistics systems, such as the kanban pull system mentioned earlier, as it facilitates the identification and storage of merchandise information.

A lean production system must be designed to flow. Automation should be selected after deciding how best to improve the flow and adapt to it. It should also be noted that, after implementing lean improvements, selective automation has the potential to add value and further reduce human variability.

6 Conclusions

With the information presented on Lean Manufacturing and Industry 4.0, it is possible to observe the possibilities of improvements that the proper combination of the two tools can bring to manufacturing processes. Industry 4.0 is already a reality in industries, as well as the search for continuous improvement. Therefore, it is expected that within companies there are people interested and willing to apply Lean Automation.

For future work, this initial research project suggests the practical application of the Kanban Pull System and visual management, consequently data could be collected and there will actually be a study of how the application of lean automation improves companies' manufacturing and also the daily lives of employee.

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Implementation and Comparison of Low Power Wireless Protocols in a Mesh Topology

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Abstract. The Internet of Things is one of the upcoming networking that helps bridge the gap between the real world and the virtual world by enabling monitoring and control of certain elements.

The critical point for the future is the design with low power wireless technologies based on mesh topologies because it is very attractive due to their reliability and scalability of failures. In this report, we provide an overview of the most popular short-range wireless communication standards, such as BLE, Zigbee, and Thread technologies, comparing their key features and behaviors in terms of various metrics, network topology, security, quality of service, and power consumption.

This study presented in this work will be useful to the application in selecting the best technology for a concrete use of the low power wireless protocol.

Keywords: IoT , BLE , Zigbee, Thread.

1 Introduction

The combination of advances in hardware and networking has given rise to the Internet of Things (IoT), which aims to enable everyday objects to collect and exchange data over the Internet through small sensing devices.

Millions, if not billions, of Internet sensors embedded around the world provide an incredibly rich set of data that companies can use to collect data on the safety of their operations, track their assets and create new business opportunities. These objects have a variety of computing and sensory capabilities and offer complex interactions with their environment or users. The scope of IoT applications is vast. By installing sensors on objects such as lamps, refrigerators, heaters, fans, it is possible to monitor and control them remotely in a wide variety of applications that fall into two categories as shown in Figure 1 : short-range applications such as smart home, healthcare, and personal applications, and long-range applications such as smart cities, transportation, and industries.

This work focuses on short-range wireless technology: BLE, Zigbee and Thread that support mesh networks to extend applications that provide long distances with low transmission power and can achieve high reliability. We compare them based on their characteristics and behaviors in terms of various metrics, network topology, security, quality of service, and energy consumption.

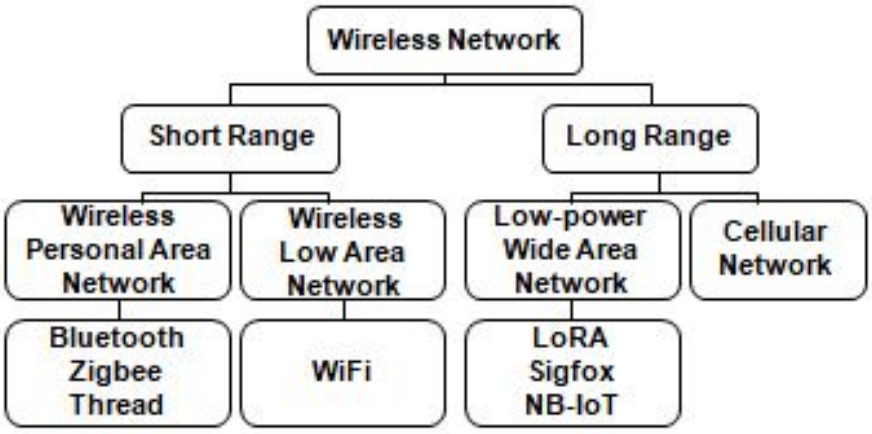

Fig. 1: A Wireless Network.

2 Mesh protocol analysis

2.1 Zigbee

Zigbee's technology is a wireless communication standard that defines a set of protocols for use in low-power, short and medium-range wireless networking devices such as sensors and control networks. It operates in unlicensed bands such as 2.4 GHz. There are also devices that use a different set of frequency bands such as 784 MHz, 868 MHz and 915 MHz in China, Europe and the United States [3].

Zigbee relies on the physical layer and medium access control defined in IEEE 802.15.4 to create a wireless mesh network. The Zigbee specification defines the network layer and the application layers. Each network must have a coordinator device and multiple routers to extend network-level communication.

2.2 Thread

Thread is an IPv6-based mesh networking protocol developed to directly and securely connect products around the home to each other. It was developed to run on low-power, low-cost. The Thread network, from the application layer to the physical layer, is not a new standard, but a combination of existing standards. Thread uses a combination of standards, including CoAP, UDP, DTLS, 6LowPan, vector routing and LR-WPAN [2]. Each network must have a leader device and multiple routers to extend network-level communication, additionally the role of a leader in a Thread network can be reassigned to another router if the original leader becomes unavailable.

2.3 Bluetooth Low Energy

The Bluetooth mesh network is based on Bluetooth Low Energy (BLE) technology operating at 2.4GHz. BLE mesh networks use scanning and advertising to achieve communications in the same way as BLE technology. It contains 3 advertising channels and 37 data channels. Bluetooth mesh uses managed flooding to transmit messages

through the network [1].The Bluetooth mesh network defines its own application layer, called the mesh model, which is identified by the model ID.

2.4 Comparison of three wireless protocols

Table 1: Physical layer parameters of BLE, Zigbee, and Thread.

Specifications	**BLE**	**Zigbee**	**Thread**
IEEE Standard	802.15.1	802.15.4	802.15.4
Frequency Band	2.4GHz	2.4GHz,868 MHz,915MHz	2.4GHz
Bandwidth	1mbps	250kbps	250kbps
Range	10m	1-100m	30m
Routing	Managed Flooding	Full Routing	Full Routing
Protocol layering	Network and Application	Network and Application	Network
Cloud connectivity	Gateways	Smartphone /Gateways	Border Router/Gateway

2.5 Results and Discussion

The nRF52 SoC comes with the Thread, Zigbee and Bluetooth Low Energy protocol stack.Thus, to compile and run software on nRF52840 devices, Segger's Embedded Studio IDE, nRF connect, and J-link are used to debug and run code on the devices. On the host device PUTTY, a serial terminal, is used.

a. Thread

The table 1 shows the result of creating the mesh network with different configurations. The network was created with 5 devices, including a leader, 3 routers and a child, each device having its own IP address. For example, the following addresses are those of the leader, whose first address is used to route traffic and identify the location of interfaces and the second address is created when the device is connected to the network; the third address is used to communicate with other interfaces on the same network; and the fourth one is created with the mac.

- Leader Anycast Locator(ALOC): fdde:ad00:beef:0:0:ff:fe00:fc00
- Routing Locator(RLOC): fdde:ad00:beef:0:0:ff:fe00:dc00
- Mesh-Local EID(ML-EID): fdde:ad00:beef:0:f633:979d:cf70:c041
- Link-Local Address(LLA): fe80:0:0:0:b458:45c4:7753:8182

User	COM13	COM11	COM12	COM14
PAN ID	0X1234	0X1234	0X1234	0X1234
State	Leader	Router1	Router2	Router3
EXT Mac	b65845c477538182	3fe4c90dbe2be0c0	36a7aeca27b83e6f	46c5dde91469ddf4
Master key	00112233445566778899aabbccddeeff			
EXT PAN	dead00beef00cafe			
Channel	11			

Fig. 2: Characteristics of joining devices.

The figure 2 above concludes all the characteristics of each device of the network.

The routing table is established when the mesh network is created as shows the figure below the leader routing table, which is populated with a compressed form of a local mesh address for each router and the appropriate next hop. It also contains the path cost and age, which define the number of nodes to traverse when sending data from the current node to a destination node. The routing table is established when the mesh network is created.

Also get the neighbor table for each device that contains the average of the RSSI and each extended Mac.

✓ **COM13 : LEADER**

ID	RLOC	Next hop	Path Cost	LQ In	LQ Out	Age	Extended Mac
11	0x2c00	15	1	3	3	15	3ef4c90dbe2be0c0
15	0x3c00	11	1	3	3	4	46c5dde91469ddf4
26	0x6800	11	1	3	3	13	36a7aeca27b83e6f

Fig. 3: Network leader routing table

b. Zigbee

The following table explain the operations and commands performed by coordinators, routers to form or join a network. The coordinator is the only device that can start a network, so every Zigbee network must have a coordinator. It is responsible for selecting an unused operating channel, PAN ID, security and stack profile for a network that, routers must discover and join a valid Zigbee network. When a router joins a network, it receives a 16-bit address randomly chosen by the device that authorized the connection.

Also in Zigbee, the Ping command is used to show the time between sending and receiving a packet, and as shown in Figure 5 get a binding table that defines the relationships between two devices at the application layer. Figure 4 below concludes all the characteristics of each device in the network.

Username	COM17	COM16	COM18	COM19
PAN ID	9943	9943	9943	9943
Role	Coordinator	Router 1	Router 2	Router 3
Short address	0000	7059	5E85	5Dc4
Eui64 address	f4ce36e27cf78d03	4ce3679f2448239	f4ce36b34448da7b	f4ce3614e2d676ab
Network key	00112233445566778899aabbccddeeff			
Channel	16			

Fig. 4: Network leader routing table

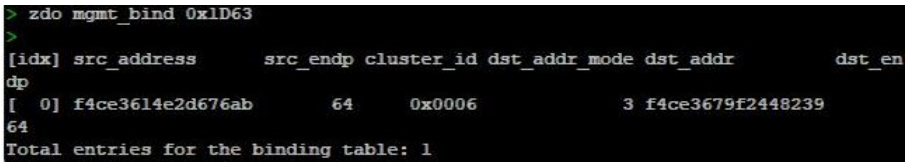

Fig. 5: Network leader routing table

c. BLE

For the BLE, five devices are connected so that each device can send data to any other, and these are received in the "nrf connect" application. For example, after connecting the devices to the mesh network, to change the status of the LED of one device, all other devices are notified in the same way. Also, access to the characteristic value of a device to all other devices, and each device can get the characteristic value in BLE.

3 Conclusion

Through the mesh, a node can communicate efficiently with another node by sending messages along a specific route. This has a positive effect on mesh throughput and can reduce latency, so a routing mesh is better than a flooding mesh because it provides more efficient communications and predictable performance.Finally, the Thread network is an optimal choice because it was easier to control IoT products and systems from personal devices such as cell phones or tablets, and this technology is expected to grow significantly over the next few years.Thread has great potential and has the added benefits of Wi-Fi like functionality.

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