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Keyword: Rover, Inspection, Cleaning, Ducts, Flexibility, Eulerian Video Magnification.

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Abstract

This paper presents a diversied artifice of a Rover robot prototype in order to inspect abnormalities in air conditioning ducts and ventilation through an integrated rotating high-resolution camera system Eulerian Video Magnification is a method capable of revealing temporal variations of a body in videos that are impossible to see with the naked eye. Using this method, it is possible to visualize the flow of microorganisms present in the ducts, in which the images are R.W. transmitted in real time to the operator, allowing the cleaning with rotating brushes that adapt themselves according to the pipeline geometry, linked to the rover making the removal of impurities which are found on the walls, as well as the application of fungicides and bactericides, and finally the mechanism structure allows the manipulation of small objects held by a claw, which ensures greater operating flexibility compared to existing systems on the market. Due to weather problems being the main responsible for the considerable rise in temperature around the world, this has led man to seek ways by which people have comfort in both residential and industrial context. The most widely used alternative to soften or even solve this problem indoors has been the use of air conditioning systems. Despite the many advantages that these systems provide, there is great concern with the quality of air being supplied to the user according to the procedures and requirements of NBR 15848: 2010.

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1. INTRODUCTION

"Robotics is the intelligent connection of perception to action" (Brady, 1984). A robot is then characterized as a mechanical and articulated device that can get information from the environment through sensors and software, take decisions based on this information and previous settings, and interact with the environment using actuators. The cameras are sensors commonly used in robots, and the computing vision field addresses the problem of emulating human vision and interpreting the world in 3D based on 2D images. Computer Vision offer not only the image itself, but above all with the logical act of assuming facts about the world and using known models to infer what the image represents. (Szeliski, 2010).

In order to improve and expand the use of Rovers robots, an inquiry about the shortcomings of existing systems was held. However, they are common activities that expose workers to dangerous situations, and obviously, the use of improvement in robotics and automation to solve the problem is considered. But in

order to use these improvements, it is necessary at this time, to select the areas that present high financial returns due to the high cost of equipment. In order to use the equipment in any activity, the financial nature of the problem is considered, even at the expense of ethical issues involving the safety and well-being of workers. In order to provide the protection and cost- benefit needs, it is necessary to produce a versatile, compatible with current technologies with attractive price and agility similar to men, replacing their presence where there is a risk.

According to the Ministry of Health (BRAZIL, 1998), the worldwide concern with the quality of indoor air in air-conditioned environments and the wide and increasing use of air conditioning systems in the country are related, because of weather conditions. It is very alarming the lack of maintenance in these air conditioning ducts, both as for those who make this kind of confined service that demands a lot of work, as for those that inspire this kind of air, due to the situations in which they are found, as it is shown in Fig. 1 and Fig. 2 and can thus bring great respiratory damage, according to NBR 14679: 2012 (BRAZILIAN ASSOCIATION OF TECHNICAL STANDARDS, 2012) establishes the procedures and minimum guidelines for implementation of corrective cleaning services of treatment systems and air distribution characterized as contaminated by microbiological, physical or chemical agents.

Figure 1. Ducts with dirt accumulation.

Figure 2. Insect presence housed in ducts.

Due to the complexity of HVAC systems, it is mandatory for companies to have their maintenance plans, guidance and control of air quality in air-conditioned environments, with technical responsibility annotation of a mechanical engineer and registered by the CREA (Regional Council of Engineering and Architecture). This technical manager shall provide technical maintenance reports and physical, chemical and microbiological reports about air quality available at any time. Thus, air-conditioning ducts offer everyday risks in theaters, shopping malls, buildings, mainly in hospitals or in any public place where there is an air-conditioning or installed ventilation system, the danger is imminent due to accumulation of dirt.

2. INNOVATION CONCEPTION

Professionals who used to perform the task of performing maintenance on ventilation and air conditioning ducts, stay in extremely unhealthy conditions, labor-intensive and high-risk professional areas due to the high content of dust and micro-organisms, it also creates a situation where the professional's health is exposed to various diseases caused by bacteria and fungi, so it opposes the precariousness of this type of maintenance which exposes the health of those that breath in these types of air-conditioned environments, everyday risks, to perform this function using a mobile robot using the Eulerian Video

Magnification shown extremely efficient since the bacteria are localized precisely, less work, because the very interconnected system to the robot is in charge of the extermination of these causative agents of disease, the process is a relatively low cost compared to existing systems, allowing not only corrective maintenance, more particularly around preventive system.

2.1 Conventional Systems

Most equipments uses direct contact of the operator to perform the operation and the partial disassembly of the ducts to analyze the conditions, which requires a visual inspection, an example is the large pipes that require a long time to carry out this type maintenance and also site interdict, then what should be an easy activity becomes difficult and extreme complication, reflecting unmotivation by those who go through this process.

3. PROJECT AND MATERIALS

Robotic systems are electronic and mechanized devices designed to perform scheduled work or controlled by humans to provide their needs. It can be divided into two main parts: software (program, which has no physical existence) and hardware (physical machine parts, engines, gear, weapons, sensors, etc.).

3.1 Software

The Software is classified as a logical part, a program written in a language interpretable by a machine (the processor of a computer or other equipment) and allows algorithm execution to perform tasks for which the software was designed. These programs consist of a sequence of instructions (commands) and data statements, which are storable on a digital environment defining how the hardware should behave when they do not conduct drive sensors or switches.

3.1.1 Eulerian Video Magnification

The underlying technology used by the software is called Eulerian Video Magnification (EVM), which essentially tracks the variation of individual pixels over time and then exaggerates those differences

3.2 Hardware

3.2.1 Processing

Hardware component responsible for processing data and turning it into information. It's called CPU (central processing unit) and the data is transmitted to the board on which the information will be processed, what in turn transmits them to input and output terminals (I / O) as actuators, sensors, cameras and other devices.

3.2.2 Motors and Actuators

The engines are the driving force responsible for the movement of equipment, devices that convert electrical energy into mechanical energy. This mechanical energy is developed by rotating a shaft that

rotates at a certain speed and torque in which the rotation axis provides movement to the plant or parts of it.

Physical quantities involved as power, torque and speed are the three basic variables that must be considered under the terms of the movement to be made.

The servomotors are commonly used, composed by an internal control system which checks the input position with the output position and a DC motor and a reduction gear responsible for the increasing of its torque.

4. DEVELOPMENT

4.1 Intuitive Control Concept

The main feature that distinguishes the configuration of this Rover from others is the use of techniques and methods used in other areas, developing a system that can have robotics advantages over the operator's safety, a decrease in the amount of PPE and it adds robots flexibility with concept of intuitive operation, where the operator does not need intensive training to handle it, as through a camera.

Through an enhanced digital microscopic camera USB 1000x, connected to the video Eulerian software Magnification (EVM), enables location of the bacteria, especially legionella, belonging to the mesophilic group, which are the worst cause of fatal respiratory diseases. The thermal application enables classifies it according to the optimum temperature for growth of between 30 and 37 ° C, this being the same temperature found in the cooling ducts. This technology allows you to take the variations in temperature and movement and converts them into frequency, which facilitates locating outbreaks of bacteria present in the ducts and apply the appropriate cleaning method.

This equation to estimate the size for a spatial filter needed to reveal a signal at a certain noise power level, as in Eq. (1).

$$s(\lambda) = s(r) = \sigma'^2 = k\frac{\sigma^2}{r} \quad (1)$$

Where S(λ) represents the signal over spatial frequencies, and since the wavelength, λ, cutoff of a spatial filter is proportional to its radius, r, the signal may be represented as S(r). The noise power, σ^2, can be estimated using to the technique. Finally, because the filtered noise power level, σ'^2, is inversely proportional to r^2, it is possible to solve the equation for r, where k is a constant that depends on the shape of the low pass filter. Finally, the magnified signal is added to the original image and the spatial pyramid collapsed to obtain the final output as shown in the Fig. 3 below.

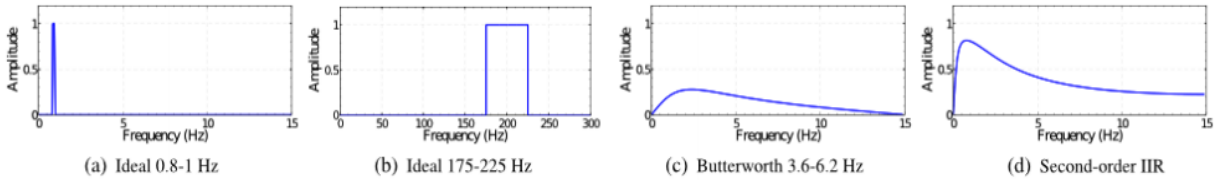

Figure 3.Examples of temporal filters.

4.2 Development Criteria

In order to make the idea to work, it was necessary to think about any method for the robot to transmit the image to the operator to enable In order to make the idea to work, it was necessary to think about any method for the robot to transmit the image to the operator to enable not only the autonomous movement inside the ducts but also the realization of inspection in real time to track outbreaks of bacteria housed in the same. For this, a wireless interfacing was used to connect the robot to the operator using the rotating brushes to perform the cleaning of it, allowing the manipulation of objects through a claw with parallel fingers and the application of bactericides and fungicides by the robot's integrated system.

After the research about the methods used in robotics, such as handling robots explorers and Rovers that aim to examine a particular environment or space and reveal through sensors and camera physical and biological characteristics, developing something that that is simultaneously feasible, flexible and affordable, using the virtual presence of men where they can't access, or where their presence is undesirable.

4.3 Elaboration of Mechanical Design

In the initial design process, it was developed a 3D modeling of the prototype using the CAD tool, shown in Fig. 4 below, its structural part, which was subsequently used in the mechanical manufacturing process, sharing the possibilities of improvements regarding the cost-benefit, also facilitating the construction of the prototype to sketch the operation.

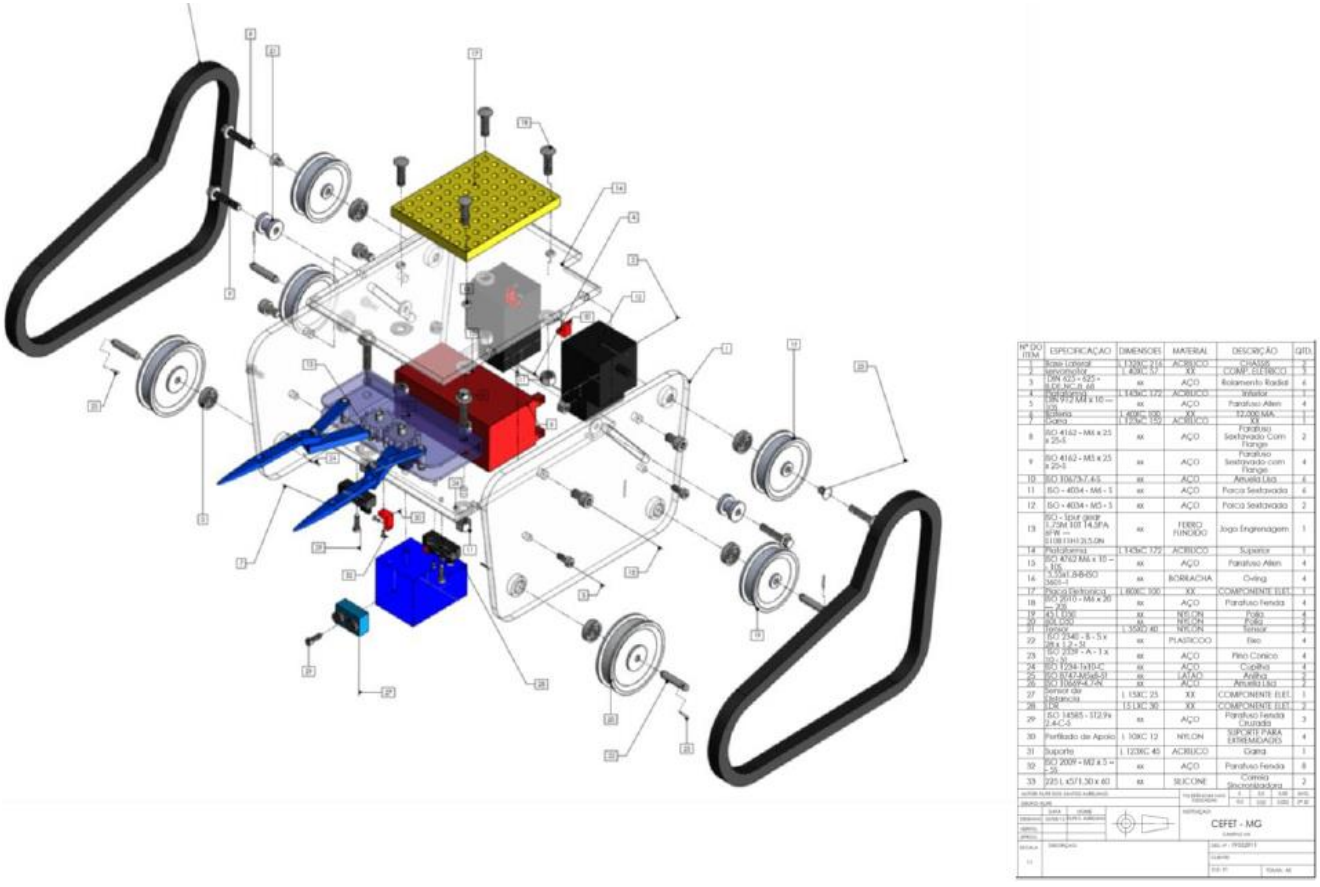

Figure 4. Structure Mechanics.

4.4 Displacement

In its displacement, it was expected the use of wheels, however analyzing in depth, it was found that the use of mats becomes more feasible because they increase the adherence to the ground and, consequently, its tensile capability in difficult terrain, allows the distribution of the prototype's weight evenly over the surface areas of the mat and curves around its own axis which does not occur with conventional wheels, thereby providing the shift in air ducts and ventilation as shown in Fig. 5 below, with easier adjustment.

Figure 5. Locomotion by mats in a duct.

4.5 Disposal of Electronic Components

The Electronic parts that compose the Rover are better characterized and detailed in the illustration of Fig. 6, where it makes use of a 6V lead battery for the actuators and a Lipo 11.1V battery power for the hardware Raspberry Pi B charging, which ensures a range of three and half hours without interruption when the exhausted batteries, automatically has a feed by an external source. The IC offers 74HC14N buffers able to transform input signals, well-defined, free of noise on its outputs which are connected to the actuators and the H bridge that makes the reverse rotation.

Figure 6. Disposal of Electronic Components.

4.6 Communication Interface

In the onboard system control, the Raspberry Pi B platform features including camera, wireless connection to handling and a greater response speed to the other existing controls, as this type of robot uses robotic vision applications including inspection, classification, navigation, recognition and manipulation. Through the Secure Shell (SSH) communication interface is made the robot navigation using the Raspibian Operating System (GNU Linux), a software application in C language WiringPI library, to control their movements, environmental analysis and manipulation objects, communication topology is most characterized in the flow chart in Fig. 7 below, demonstrated its flow control.

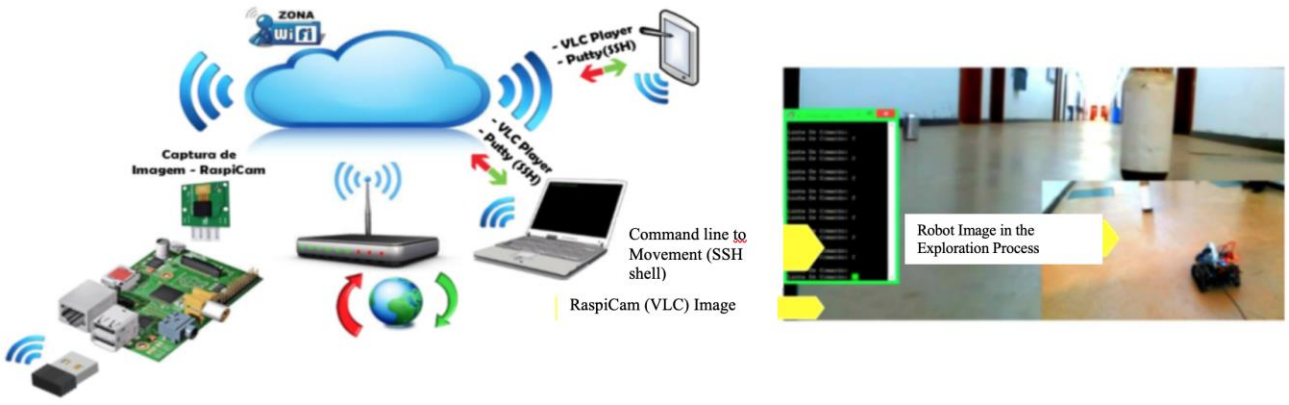

Figure 7. Communication Interface.

5. ANALYSIS

After the research development, it was possible to build the functional prototype that behaved as predicted in simulations where the operator needs only a mobile phone or a computer for handling the distance of Rover robot to perform cleaning and inspection of these products without the need of disassembling them or interdicting the site to carry out the task, performing the same service that was done by a team of technicians that was imposed to unhealthy situations. Already sketching out the system development viability for industrial use, but it is still needed to be characterized more effectively that even at the prototype stage, already shows characteristics that enable its use.

A practical test was held as it is seen in Fig. 8, demonstrating the feasibility of implementing cleaning and inspection of these pipelines, performing control of their movements through wireless networks by a mobile phone, making the use of your IP address to be access to Rover, in a simulation of the real physical system (SFR). This demonstration was also useful for prove the efficiency of developed controls that act friendly and intuitive, even in delicate tasks such as inspection.

Figure 8. Simulation of the real physical system.

The problems and solutions using the Robot Rover can be listed as:

• Problem: The air pollution in public places has become of great concern, the lack of maintenance in these air conditioning ducts, as those that inspire this kind of air can thus bring great respiratory damage.

• Solution: In order to analyze the duct, the Rover robot was connected to the Eulerian Video Magnification software in conjunction with a microscopic camera, in which it was possible to analyze the flow of bacteria in certain regions, as shown in Fig.9 (bacteria indicated in the regions graph black). In which it used a macroscopic camera that enabled their precise and responsive displacement in the ducts.

Eliminating direct contact these unhealthy places and allowing not only corrective maintenance more mainly preventive in which it inspects the system and determine the level of contamination where it is.

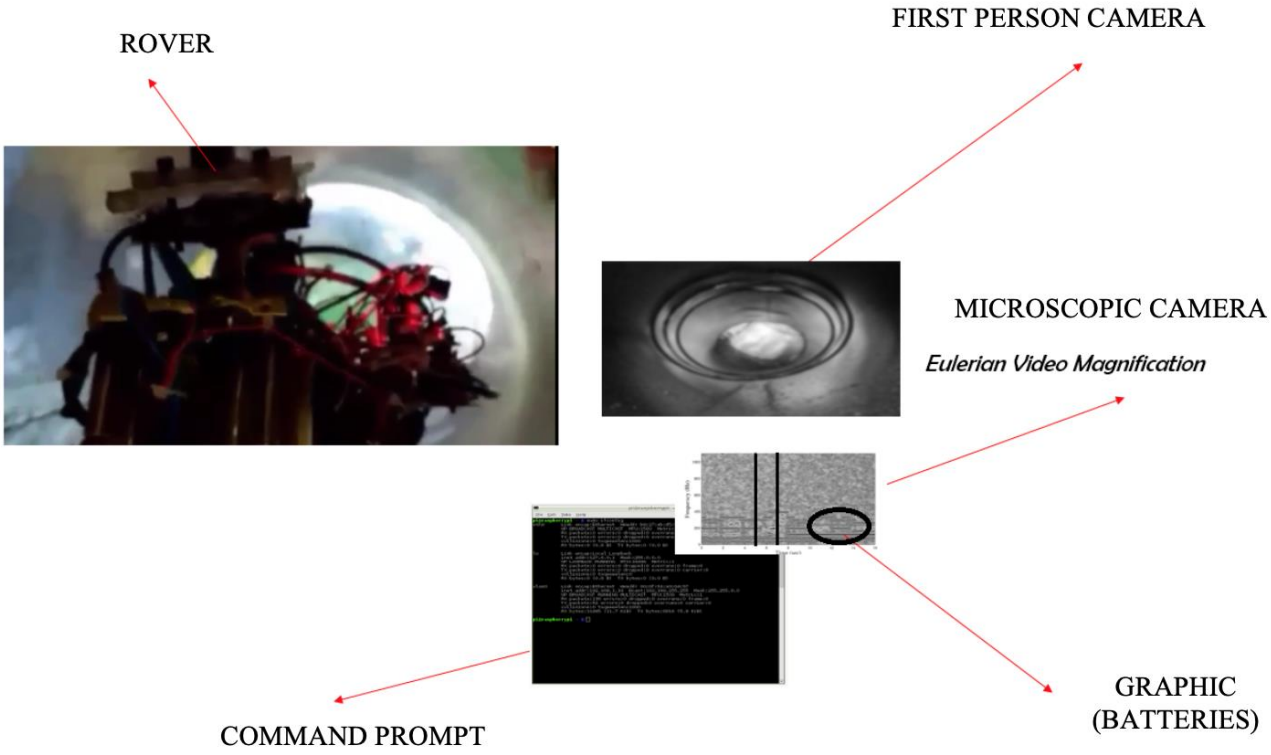

Figure 9. Microscopic analysis.

6. DISCUSSIONS

This study is different and can be considered an innovation by presenting a diversified artifice of a robot prototype explorer Rover, to inspect abnormalities in air conditioning ducts and ventilation through a rotating camera in which the images are transmitted in real time to operator, another increased microscopic camera 1000x connected to Eulerian Video Magnification software (EVM) and also perform cleaning with rotating brushes coupled to the Rover making the removal of impurities which are employed on the walls of these conduits, applying fungicides and bactericides and, also, the engine structure allows the manipulation of small objects held by a gripper, which ensures greater operational flexibility compared to existing systems on the market.

This is considered a simple innovation, its implementation would take men to a new era regarding occupational safety and achieving the explored area of inhospitable environments, allowing with no risks the performing of dangerous activities that today mutilate and degrade human health, in a totally safe and viable way.

7. ACKNOWLEDGEMENTS

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9. RESPONSIBILITY NOTICE

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