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APPLICATION OF "MECHATRONICS"

ALPHA I (FIRE FIGHTING ROBOT)

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Abstract

This paper is designed to introduce the reader to the concept of "The application of Mechatronics". Human error is still one of the most frequent causes of catastrophe and ecological disasters. The main reason is that the monitoring systems concern only the state of the processes where as human contribution to the overall performance of the system is left unsupervised. Since the control instruments are automated to a large extent, a human operator becomes a passive observer of the supervised system, which results in weariness and vigilance drop. The ALPHA-I technology Fire-fighting is an important but dangerous occupation. A fire-fighter must be able to get to a fire quickly and safely extinguish the fire preventing further damage and reduce fatalities. Technology has finally bridged the gap between fire-fighting and machines allowing for a more efficient and effective method of fire-fighting. Robots designed to find a fire, before it rages out of control, can one day work with fire-fighters greatly reducing the risk of injury to victims. This project involves designing a project which can locate and extinguish a fire.This paper is about the hardware, software, benefits and interconnection of various parts involved in this very technology.

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1. INTRODUCTION

Robot is defined as a mechanical design that is capable of performing human tasks or behaving in a human-like manner. Building a robot requires expertise and complex programming. It's about building systems and putting together motors, solenoids, and wires, among other important components. A fire fighter robot is one that has a small fire extinguisher added to it. By attaching a small fire extinguisher to the robot, the automation put out the fires it detects via RF module by human controlling it from the very distance. The fire detection scheme to be put into use is relatively free of false alarms, it is anticipated that it will not overreact in non-fire simulations. ALPHA-I is equipped with the camera for the display and is controlled through RF Receiver which is placed on its body and RF Transmitter which works as a medium for controlling the actions. The RF module works on the 433MHz and works up to 60m. This ALPHA-I robot can be used for dangerous tasks, such as disarming bombs, extinguishing fire, etc. They can work where it is too dangerous for human beings. A primary purpose of this undertaking is to "provide an incentive for the robotics community to develop what will be a practical application for a real-world robot". Although it is merely a simulation of a real-world scenario, it requires the designers to use practical techniques to create useful designs. The project serves as an example of what robots can do on a larger scale.

2. OBJECTIVE

The objective is to build a robot, which will extinguish a fire in the server's rooms which are highly prone to fire. A candle will represent the fire, which has started in the home and which the robot must find and then extinguish. For this reason, a light sensor cannot be used to detect the fire. In order words, the robot must be able to make ambient light reading as part of its design complementation. The robot will sense that flame by the help of fire sensor. It will be having a wireless camera on its head that will show the exact location of the fire on laptop or desktop via wireless transmission. Now the whole functioning will be handled manually from the distance, which will reduce human life risk and will increase efficiency. Alpha *I* can also be used for the detection of mines. Thus, it is used in both small areas and field areas.

3. FRAME DESIGN

The frame design of Alpha-*I* will consist a round/square base with 3-4 wheels. We will be using DC gear motors instead of servomotors because in gear motors we need not to do any sort

of programming. Up till now we have decided to use Lego blocks to construct the frame. The Lego blocks ease the process of constructing the robot since all the blocks were designed to fit each other. Instead of having the gears lined up horizontally the gears would be redesigned vertically. The upper body consists of the arm which will be separated into two points and there will be total 360 deg. rotation of the robot arm. The upper portion of the arm will comprise of the wireless camera. We will be placing a sort of bucket or a container to hold water on the body.

The gear ratio remained 27:1 since the DC motors supplied by Lego usually spins too fast with little torque. Gears had to be attached into three stages. Each stages having an 8-tooth pinion gear with a 24-tooth spur gear. This process insures that the wheels had enough force to push or grip against the floor to move. Each wheel has its own transmission and motor. This was designed so that when the robot needed to turn, one of the wheels would lock up while the other wheel would run. The goal for this design was to be able to move 5 pounds. While the transmission design proved to be a success, the frame of the robot could not withstand the load. The bars and the axle of the robot would bend at a point where adding more support would increase the size and weight of the design. Another problem that was encountered was the robot could not turn due to bending of the axles.

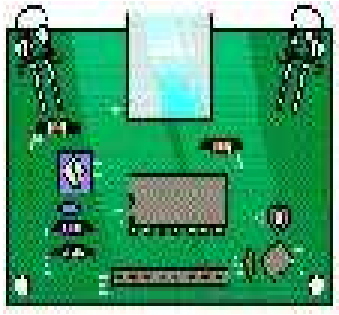
Due to this problem, we decided to build a robot from scratch. Using the same configuration and design of the first Lego prototype, the second robot was constructed with brass rectangular tubing and steel angles. Our first attempt to construct this robot came to a standstill. This problem was due to inaccurate drilling for the shafts without a press drill. Continuation on construction for this frame would cause inaccurate navigation for the future.

4. TRAIN DRIVE

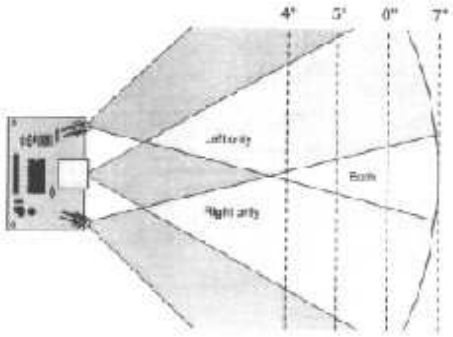
The drive train of the robot consists of two remote control (RC) DC gear motors. These motors will provide 360 degrees of rotation. A normal RC gear motor has only 180 degrees of rotation. By the combination of the 2 motors we'll be getting 360 deg. rotation. Same is the case with the robot arm. Removing the stopping tab we can eliminate this restriction.

5. FIRE DETECTION SCHEME

To detect the flame from the candle the team thought about implementing a motion detector to detect the wavelength of the flame. We decided on using an IRPD (infrared proximity detector) kit from lynx motion. With this the robot would be able to sense an object in the front left, front center, and front right. in order to detect the flame we will need to calibrate it to detect the flame of a candle. Another way, which we just recently found out about, is to use a silicon photo detector with a long-pass filter and calibrate it to detect candlelight.



6. IRPD



Signal spread of the detector.

When the candle flame is spotted in the range of this detector it the robot will be able to come in on the position of the flame, come closer, and put it out. Same is the case with mine detection as it will detect it via manual controlling.

7. NAVIGATION SCHEME

Since shaft encoders are expensive and the pricing will be not within our budget, so we decided to use the ENCODER-DECODER ICs. Then this whole device will be controlled by any person by the help of two controllers. A grid array will be implemented for the main route and sub-grids for each room once the robot enters each room. In order for the robot to navigate using the grid the robot will calculate a system of equations for each length it will run.

8. POWER SUPPLY

Rechargeable batteries were the power supply of choice for the robot. Combined with basic line regulation rechargeable batteries provide clean, reliable power, and allowed reuse of the batteries when depleted. The selection between different types of batteries was made based on size and power requirements.

9. BATTERIES

Due to our size constraints, anything larger than AA size batteries would be too large for the robot. However, the batteries must offer enough charge capacity to power the robot for a reasonable amount of time. Starting with the minimum voltage requirements of our linear regulators and working our way down to the current requirements of the motors, we determined our power requirements to include a 7 Volt supply capable of providing at least 1 Amp of peak current, and 500mA of continuous current. Our choice of chemistries included NiCad, NiMH, and Li-Ion. Li-Ion batteries were too difficult to charge. In the AA size, NiCad batteries offered charge capacities of up to 900mAH, whereas NiMH offered capacities to 2000mAH.

10. OVERALL FUNCTIONING OF ALPHA-I

This is the model with a rectangular base equipped with four wheels. The rear wheels are fitted with two motors of rating 100 r.p.m. and voltage requirement of 5-24 V. Apart from this the mechanical structure is equipped with a wooden scale with acts as a robot arm which consist of a pimp and a camera on the top. A pump is used inject the water for extinguishing the flame which is detected by the heat sensor. The camera mounted on the top helps to give the display on the screen of laptop or television. The base consists of RF Receiver with RF module, small bucket for carrying water and a motor for pumping out water. The robot arm is rotated 360 degrees via a motor or rating 10 r.p.m. The Transmitter consists of HT-640 IC along with switches to control and monitor the motors which is responsible for the movement with the regulator IC-7805 for providing regulated +5V voltage to the circuit. The RF module enables communication between two modules from the distance of around 40-60 meters in our project.

Alpha-I is the outcome of combined functioning of various modules. These modules are the:

- The Transmitter module
- The Receiver module
- Heat Sensor module
- Display module

The transmitting and the receiving module works as a controlling unit. This means that the transmitter and the receiver unit is used for the navigation of the robot through the areas and helps to approach the areas which are the victims of fire. The Heat sensing module senses the heat as where the fire is present in the control rooms or in the buildings, etc. The heat sensors are of various types we have done this very job by the use of thermistor and variable resistor. This is the separate circuit. Last is the display module, which is done by the help of web camera, RF module and any laptop or television. For the display to be on the laptop it is necessary that there should a tv tuner. Through RF module the video signals from camera is sent to laptop on which the exact display is detected. On basis of this display, we can maneuver the robot by controlling unit and will extinguish the fire by the help of the water which is pumped out from the container present over the robot's base.

11. RELAYS AND LEDS USED

A relay is an electrically operated switch. Many relays use an electromagnet to operate a switching mechanism mechanically, but other operating principles are also used. Relays are used where it is necessary to control a circuit by a low-power signal (with complete electrical isolation between control and controlled circuits), or where several circuits must be controlled by one signal. A simple electromagnetic relay consists of a coil of wire wrapped around a soft iron core, an iron yoke which provides a low reluctance path for magnetic flux, a movable iron armature, and one or more sets of contacts (there are two in the relay pictured).

A light-emitting diode (LED) is a semiconductor light source. LEDs are used as indicator lamps in many devices and are increasingly used for other lighting. Introduced as a practical electronic component in 1962, early LEDs emitted low-intensity red light, but modern versions are available across the visible, ultraviolet, and infrared wavelengths, with very high brightness. When a light-emitting diode is forward-biased (switched on), electrons are able to recombine with electron holes within the device, releasing energy in the form of photons. This effect is called electroluminescence and the colour of the light (corresponding to the energy of the photon) is determined by the energy gap of the semiconductor. LEDs are often small in area (less than 1 mm^2), and integrated optical components may be used to shape its radiation pattern.

12. DESCRIPTION OF WIRELESS CAMERA AND TUNER

Wireless security cameras are closed-circuit television (CCTV) cameras that transmit a video and audio

signal to a wireless receiver through a radio band. Many wireless security cameras require at least one cable or wire for power; "wireless" refers to the transmission of video/audio. However, some wireless security cameras are battery-powered, making the cameras truly wireless from top to bottom.

Wireless cameras are proving very popular among modern security consumers due to their low installation costs (there is no need to run expensive video extension cables) and flexible mounting options; wireless cameras can be mounted/installed in locations previously unavailable to standard wired cameras. In addition to the ease of use and convenience of access, wireless security camera allows users to leverage broadband wireless internet to provide seamless video streaming over-internet.

A television tuner converts an radio frequency analog television or digital television transmission into audio and video signals which can be further processed to produce sound and a picture. Different tuners are used for different television standards such as PAL, NTSC, ATSC, SECAM, DVB-C,DVB-T, ISDB, T-DMB, open cable. Analog tuners can tune only analog signals. An ATSC tuner is a digital tuner that tunes digital signals only and yet some digital tuners have analog bypasses. VHF/UHF TV tuners are rarely found as a separate component, instead are incorporated into television sets. Cable boxes are set top boxes that serve as a separate tuner, and have channel 3/4 outputs for TV sets that aren't cable-ready. They often feature composite, S-video, or component video outputs so they can be used on video monitors that do not have a TV tuner, or direct video inputs. They are usually bundled with a video monitor, VCR, and/or digital video recorder (DVR).

TV tuner card are also installed on PCI computer expansion cards (or in USB device, or even as a part of video card), together with a Digital signal processor (DSP), allowing a personal computer to display and/or capture television channels. A number of earlier models were stand-alone tuners, designed to deliver TV picture through a VGA connector. This allowed viewing television on a computer display, but, of course, did not allow recording television programs by the PC.

13. ADVANTAGES/DISADVANTAGES

Advantages:

- Prevention from dangerous incidents
- Minimization of
  - –ecological consequences
  - –financial loss
  - –a threat to a human life
- The reconstruction of the course of operator's work
- Needs no micro-controller programming.

Disadvantages:

- Doesn't predict nor interfere with operator's thoughts.
- Cannot force directly the operator to work.

14. APPLICATIONS

- Can be used in record maintaining rooms where fire can cause lose of valuable data.
- Can be used in Server rooms for immediate action in case of fire.
- Can be used in extinguishing fire where probability of explosion is high. For eg.
  Hotel kitchens, LPG/CNG gas stores, etc.
- Every working environment requiring permanent operator's attention.
  -At power plant control rooms.
  -At captain bridges.
  -At flight control centers.

15.FUTURE SCOPE

The project has been motivated by the desire to design a system that can detect fires and take appropriate action, without any human intervention. The development of sensor networks and the maturity of robotics suggests that we can use mobile agents for tasks that involve perception of an external stimulus and reacting to the stimulus, even when the reaction involves a significant amount of mechanical actions. This provides us the opportunity to pass on to robots tasks that traditionally humans had to do but were inherently life-threatening. Fire-fighting is an obvious candidate for such automation. Given the number of lives lost regularly in fire-fighting, the system we envision is crying for adoption. Our experience suggests that designing a fire-fighting system with sensors and robots is within the reach of the current sensor network and mobile agent technologies. Furthermore, we believe that the techniques developed in this work will carry over to other areas involving sensing and reacting to stimulus, where we desire to replace the human with an automated mobile agent.

Of course, this project has only scratched the surface. As in the design simplifications and the implementation constraints in suggest, our project is very much a proof-of-concept. In particular, a practical autonomous fire-fighting system must include a collection of robots, communicating and cooperating in the mission; furthermore, such a system requires facilities for going through obstacles in the presence of fire, and ability to receive instructions on-the-fly during an operation. All such

concerns were outside the scope of this project. However, there has been research on many of these pieces in different contexts, *e.g.*, coordination among mobile agents, techniques for detecting and avoiding obstacles, on-the-fly communication between humans and mobile agents, etc. It will be both interesting and challenging to put all this together into a practical, autonomous fire-fighting service.

CONCLUSION

This paper has presented a unique vision of the concepts which are used in this particular field. It aims to promote technology innovation to achieve a reliable and efficient outcome from the various instruments. With a common digitalized platform, these latest instruments will enable increased flexibility in control, operation, and expansion; allow for embedded intelligence, essentially foster the resilience of the instruments; and eventually benefit the customers with improved services, reliability and increased convenience. The nineties witnessed quantum leaps interface designing for improved man machine interactions. The Mechatronics application ensures a convenient way of simplifying the life by providing more delicate and user friendly facilities in computing devices. Now that we have proven the method, the next step is to improve the hardware. Instead of using cumbersome modules to gather information about the user, it will be better to use smaller and less intrusive units. The day is not far when this technology will push its way into your house hold, making you more lazy. This paper presents the major features and functions of the various concepts that could be used in this field in detail through various categories. Since this initial work cannot address everything within the proposed framework and vision, more research and development efforts are needed to fully implement the proposed framework through a joint effort of various entities. This autonomous robot successfully performs the task of a firefighter in a simulated house fire. Benefited from this technology, since the expense of activating other types of fire extinguishers may outweigh that of a robot, where product stock could be damaged by imprecise fire control methods.

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