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Swarm Robotics In Fire Emergency Situations

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ABSTRACT: *In a variety of emergency situations robot assistance has proved highly valuable, providing remote and thus safe access and operation. There are many different forms of human-robot interactions allowing a team of human and robots to take advantage of skills of each team member. A relatively new area of research considers interaction between human and a team of robot performing as a swarm. This work is concerned with the interactive use of autonomous robots in fire emergency situations. In particular we consider a swarm of robots capable of supporting and enhancing fire fighting operations co-operatively and we investigate how fire fighters in the field work with such a swarm. This paper outlines some of the key characteristics of these emergency situations. The paper addresses the use of assistive swarm robotics to support fire fighters with navigation, search and fire extinguishing operations. The paper ends by linking current expertise with current features of emergency related interaction design.*

Keywords - *Swarm Robotics, Fire Extinguisher*

I. Introduction

The Agricultural The term Swarm Intelligence, first proposed by Gerardo Beni, describes the kind of smart or purposeful collective or co-operative behaviors observed in nature, most dramatically in social insects. The past ten years has seen growing research interest in artificial systems based upon the principles of swarm intelligence. In such systems, individual agents make decisions autonomously, based only upon local sensing and communications.

Artificial systems based upon a swarm of physical mobile robots (hence the term Swarm Robotics) have been shown to exhibit very high levels of robustness and scalability. Potential applications for swarm robotics might include a swarm of marine robots that find and then contain oil pollution; a swarm of search-and-rescue robots that enter the ruins of a collapsed building to look for survivors and simultaneously map its interstices; or in-vivo nano-bots that seek and isolate harmful cells in the blood streams - a kind of artificial phagocyte. [6]

The interest here is that although the robots in a swarm are primarily autonomous, they are designed and configurated to address an overarching requirement of assisting humans in search and rescue. Two types of robot operation to support the human firefighters are distinguished:

• First employing the robot swarm as a means of gaining essential information about an incident prior to engaging with it.

• Second employing the swarm as an aid to firefighters once they engage with the fire incident.

The aim of this paper is to present our grounding in designing the human-robot swarm interface for supporting fire fighting operation. This is supported by initial domain research to ensure that the robots and related infrastructures properly comply with and support existing human practice and rules. The safety of the human firefighters is the highest priority in such operations.[1]

Our proposed robot swarm operation will be shortly presented in Section IV. In addition to this, the design approach has to take account of technical constraints. One significant constraint is that the typical operating environment of a fire incident is one in which robot performance and reliable communication cannot be guaranteed

II. System And Its Components

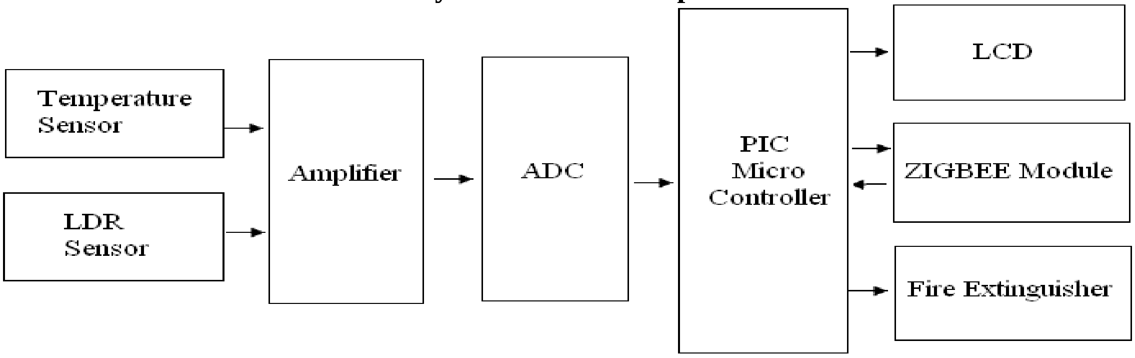

Fig 1: Block diagram

PIC Controller:

PIC controller is the peripheral interface controller introduced by microchip technology. The controller is the main functional block of our project which is interfaced with the Motors, ZigBee, LCD, Sensors etc. The controller takes the input from the keypad and gives the command to robot through field bus.

ZigBee Module:

ZigBee is a specification for a suite of high level communication protocols using small, low-power digital radios based on an IEEE 802 standard for personal area networks. Applications include wireless light switches, electrical meters with in-home-displays, and other consumer and industrial equipment that requires short-range wireless transfer of data at relatively low rates. The technology defined by the ZigBee specification is intended to be simpler and less expensive than other WPANs, such as Bluetooth. ZigBee is targeted at radio-frequency (RF) applications that require a low data rate, long battery life, and secure networking. ZigBee has a defined rate of 250 kbps best suited for periodic or intermittent data or a single signal transmission from a sensor or input device.

Fig 2: ZIGBEE Module

Temperature Sensors:

The LM35 series are precision integrated-circuit temperature sensors, whose output voltage is linearly proportional to the Celsius (Centigrade) temperature. The LM35 thus has an advantage over linear temperature sensors calibrated in ° Kelvin, as the user is not required to subtract a large constant voltage from its output to obtain convenient Centigrade scaling. The LM35 does not require any external calibration or trimming to provide typical accuracies of ±¼°C at room temperature and ±¾°C over a full -55 to +150°C temperature range.

IR Sensors:

An infrared sensor is a device (usually with supporting circuitry) that can detect infrared light (which is below the optical spectrum) for use to a purpose. Infrared sensors also have important scientific, military, security and rescue applications since they can "see" the "radiant heat energy" which is infrared radiation. This electromagnetic energy is in the wavelengths from about 750 nm, which is the lower end of the optical spectrum, to well over 10,000 nm, deep in the infrared.

Motor Encoders:

A rotary encoder, also called a shaft encoder, is an electro-mechanical device that converts the angular position or motion of a shaft or axle to an analog or digital code. The output of incremental encoders provides information about the motion of the shaft which is typically further processed elsewhere into information such as speed, distance, RPM and position. The output of absolute encoders indicates the current position of the shaft, making them angle transducers.

Fire Extinguisher:

Fire Extinguisher is used to extinguish the fire in our project. The extinguisher we have used is 500gm in weight and is easy to use. A fire extinguisher is an active fire protection device used to extinguish or control small fires, often in emergency situations. It is not intended for use on an out-of-control fire, such as one which has reached the ceiling, endangers the user (i.e., no escape route, smoke, explosion hazard, etc.), or otherwise requires the expertise of a fire department. Typically, a fire extinguisher consists of a hand-held cylindrical pressure vessel containing an agent which can be discharged to extinguish a fire.

Fig 3: Fire extinguisher

III. FIRE FIGHTING SETTING:

The emergency setting environment for the project is a single warehouse. Such warehouses usually consist of large open spaces with a variety of differing goods and materials stored throughout. Such warehouses can be as large as (400×200) m2 , and are often divided into sections separated by fire resistant walls. However, during a fire incident, smoke and fumes may cover entire sections in the warehouse. As a consequence visibility becomes an issue for firemen. This is a common concern for fire fighters, their normal training includes working fully blind-folded. A significant risk in such incidents is that fire fighters can become easily lost. There have been notorious tragic examples where firefighters died after becoming lost in the fire smoke. In the warehouse fire of 1991 in Gillender Street London (UK), two firefighters died this way, and in the 1999 warehouse fire in Worcester (USA), six firefighters lost their lives in similar conditions.[7]

Thus, the warehouse fire setting is one where poor visibility means the search and rescue is both time consuming and high risk. Moreover, a warehouse in fire may contain high quantities of toxic gases or inflammable materials. Adding to the complexity and risk of such an incident is that key information about the fire may be limited: ambient conditions, warehouse layout, the potential for flashovers are often unknown and likely to change.[8]

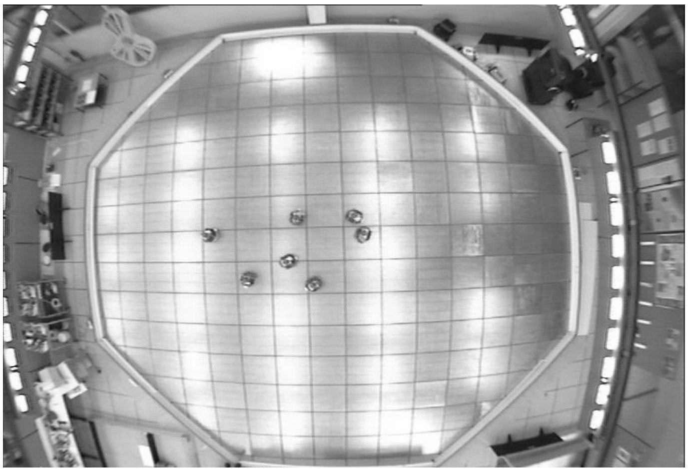

Fig 4: A Warehouse for Testing

IV. FIRE FIGHTING OPERATION

A box of scrap will be set on fire, and which the robot must find and then extinguish. The light level of the surrounding in the testing area will be determined until the day . 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. Knowledge of the surrounding light must be taken into consideration in order to make an appropriate fire sensor. Thus far, it seems like it will better to utilize a heat sensor.[5]

As soon as it detects the fire it will send an acknowledgement to the other robots with the help of ZigBee modules fitted on each robot that the fire has been detected . The other robots will come to know about the position of the robot which has detected the fire with the help of motor encoders and they will head towards fire. As soon as they reach they will extinguish the fire.[6]

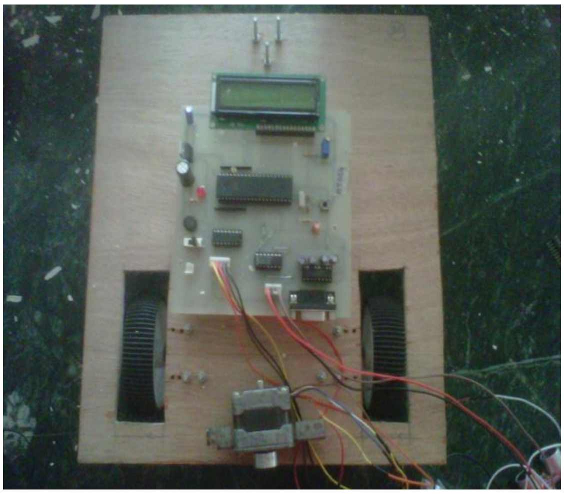

Fig 5: Robot with onboard PCB

V. SOFTWARE DESIGN

SOFTWARE USED: MPLAB:

MPLab is the software used whose features are given as below:

FEATURES:

- Flexible customizable programmer's text editor.
- Free components.
- Fully integrated debugging with right mouse click menus for breakpoints, trace and editor functions .
- Mouse over variable to instantly evaluate the contents of variables and registers.

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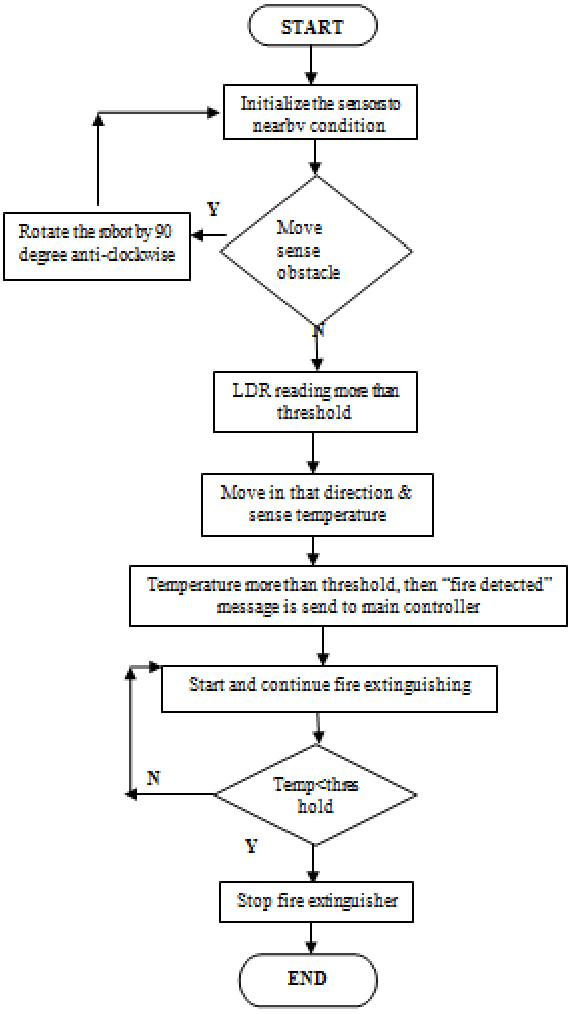
- Set breakpoints and trace points directly in editor to instantly make changes and evaluate their effects.
- MPLAB SIM, high speed software simulator for PIC and dsPIC devices with peripheral simulation, complex stimulus injection and register logging.
- Full featured debugger.
- Recordable macros.
- Simple, powerful source level debugging and built in support for hardware and add-on components.
- Auto alignment of breakpoints after source code modification.
- Trace to source correlation to compare real time data collected with original source code and comments.
- Powerful simulator stimulus generator.

HITECH COMPILER :
The compiler used is Hi-tech compiler whose details are as given below:

FEATURES:
Unlimited Memory Usage.
Eliminates the need for many non-standard C qualifiers and compiler options.
Reduces overhead required for interrupt context switching.
Optimizes the size of each pointer variable in your code based on its usage.

FLOW CHART:



VI. RESULTS:

DISTANCE (cm)	TEMPERATURE (°C)
1	38
2	36
3	35
4	34
5	33
6	33

Table 1: Result of temperature sensor

DISTANCE (cm)	LIGHT INTENSITY
5	354
10	280
15	264
20	236
25	193
30	190

Table 2: Result of LDR sensor

VII. DISCUSSION:

- **Can Swarm Robots be robust?**

In the swarm intelligence literature, the term 'robustness' has been used in a number of different ways. A swarm has been described as robust because:
1. It is a completely distributed system and therefore has no common-mode failure point.
2. It is comprised of simple and hence functionally and mechanically reliable individual robots.

3. It may be tolerant to noise and uncertainties in the operational environment.
4. It may be tolerant to the failure of one or more robots without compromising the desired overall swarm behavior.
5. It may be tolerant to individual robots who fail in such a way as to thwart the overall desired swarm behavior. [4]

We can conclude that our case study swarm does indeed merit the characterization of 'robust', although not just because of its inherent parallelism and redundancy. Our swarm's high level of robustness is a result of several factors: parallelism of multiple robots; redundancy characterized by a sub-optimal approach to the desired overall swarm functionality.

- **Can we rely on Swarm Systems?**

In this section we explore a number of possible reliability models for a robot swarm. The purpose of a reliability model is to enable the estimation of overall system reliability, given the (known) reliability of individual components of the system. Reliability R is defined as the probability that the system will operate without failure, thus the unreliability (probability of failure) of the system, Pf = 1-R. In our case the overall system is the robot swarm and its components are the individual robots of the swarm. From a reliability modeling perspective a swarm of robots is clearly a parallel system of N components (robots). If the robots are independent, with equal probability of failure p, then the system probability of failure is clearly the product of robot probabilities of failure. Thus, for identical robots

R=1-(p^N)

It is a general characteristic of swarm robotic systems that the desired overall swarm behaviors are not manifest with just one or a very small number of robots. However, the question of how many (or few) robots are needed in order to guarantee a required emergent behavior in a particular swarm and for a particular behavior is often not straightforward.[2],[3]

VIII. CONCLUSION:

The research on the human swarm interface has to tackle several very new problems. The group of robot swarm is to help the human to navigate where the human senses are failing. Furthermore, this project aims to develop novel interactions technology to maintain control and coordination between the swarm and the humans. Next steps consist of providing a full conceptual design to human - robot swarm interactions, and further the physical and operational prototype will be evaluated in full scale.

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