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Search Operations Via Swarm Based Robots

Ms. J.Gowthamy[1],Anisha Rajesh[2], Disha Dikshita Behera[3] , Anusha Chattopadhyay[4] and B.Mathangi[5]

[1] Assistant Professor, Department of Computer Science,
SRM Institute of technology
Chennai, India

[2,3,4,5]Department of Computer Science: Student 3rd year
SRM Institute of technology
Chennai, India

Abstract

The project aims to create a system that minimizes the additional risk of human life in search and detection operations in times of disasters.The operation aims to use face detection technology and swarm robotics to search and locate victims.Using human detection datasets allows the search for victims and swarm robotics allow more ground to be covered at lesser hardware costs. The combined effort of a swarm allows less need for individual maneuver and also more importantly better coordination and communication, needing for lesser additional systems to communicate between the systems.The ability to add computer vision lowers the need for direct human intervention, thus the addition of face detection.The combination of both technologies allows less collateral damage added to the search and retrieval of victims.

Keywords:Disaster, face detection, swarm, communication

1. Introduction

The system as such deals with simple mechanisms in hopes to reduce the overall cost and capital and most importantly life risk associated with disaster search and rescue.The prototype is designed to search and locate victims. Using simple robots that just search for victims and send a location to control, it performs a preliminary search. The model and maneuverer being inspired from insect swarm robots. It aims to identify the victims via image detection. The simple and ideally small models help it go under rubble making it suitable for search.We use OpenCV and its pre trained human detection haar-cascade classifier to detect the survivors and Beacons to find their location.The system robots themselves are made to act as the beacons and the detectors.

Each system robot is referred to ‘unit’ in the following sections.

2. Review of Literature

A. Initiation

First phase that is Initiation initiates the units being assigned to the field. Being based on insects in their maneuverer: they are designed to move straight into the field moving forward. The drop of the robots initiates the first move.

The units are then to move around looking at the area around them and search for faces.

B. Search

Search is initiated as soon as Initiation begins. It is the search for humans in the view of the unit.

OpenCV is used for this phase for the section. pre trained haar-cascade datasets used for the detection.

C. Contact & Communication

This occurs after Search detects a face. The unit sends a signal via beacons and hence prompting the rescue team to look into its location.

The units themselves are designed to be beacons.

D. FINAL LOOK

The final job is left up to the rescue team, as the prototype unit is as for now concentrating on search.

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3. Materials and Methods

SYSTEM ARCHITECTURE

The system itself is designed to lower the cost simplify the search as much as possible. Using comparatively crude mechanisms.

Fig. 1 System Architecture

Overview

The units are mostly supposed to operate on their own with minimal human intervention: having very simple functions on themselves. The units have their own face detection payloads and themselves act as beacons to signal the other units. The whole system has however a centralised monitor so that their actions can be viewed by a 3rd party, probably the human running the operation. The monitor also will play a central part in the end of phase 3; when the notification and details of a face is sent.

Units

Each unit is ideally supposed to work without human intervention until the end of phase 3 of the operation.

The units are designed after insects, as they are designed for ground search.

The key payloads of the unit is 1. Image detection system (camera, processor) 2. Distance detector (signaller, processor)

As per the prototype the units are solely for search

Monitor

Being the 2nd part of the System, it is for viewing function and 3rd party access. It will notify the rescue team in effect of end of phase 3. It also will be viewing the actions of all the units as the operation takes place.

The need for the monitor is evident, apart from being the part of the system that notifies the rescue team, it also will be necessary to weed out any false alarms.

Data flow

The data in the system flows both ways in between the units, however only one way in between the monitor and the unit.

The units are not designed to store any data themselves outside original programming, the data is all sent to the monitor to analyse and store.

The units do not contain any intelligence in the prototype, due to the need for simplicity for the search to enable mass production for the units in the long run. The simpler the system the reduction of costs and less chance of damage to the system.

Phase 1: which is the start of the system, requirements the drop off the units to be done manually, they move around in an automated manner to begin with.

Phase 2: which is the human detection has no requirement to contact of one unit to the others. It is a sole action of a single unit. Even though the units are designed to ensure the camera can detect light to search, there are other sensors on board which if enough light up also send a signal. However the video feed is also crucial for monitoring.

Phase 3: This is where the Units are meant to interact with each other. The units each are designed to act as beacons and sensors. This requires at least 4 prototypes as a result.

Beacons and sonar sensors are used instead of GPS for many reasons, one including that indoors GPS isn't very effective and also it requires many complex calculations.

The data of the locations of the beacons and distance tracking means that the relative locations of the units are known in the end, as the prototype doesn't account for standing beacons. This is done as there may not be position for a place to set up a beacon or sensor in an uneven playing field. **Thus the location data in this system is very relative.**

The monitor isn't responsible for control of the units, it isn't meant to send data to the units.

However the monitor serves the obvious failsafe to ensure that false alarms or misses are covered by human eyes, which will lower with more advanced datasets.

4. Results and Discussion

By analysing previous papers, we have proposed the system that has eradicated the previous invasives.The following is the table indicating for the same.

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Table. 1 Literature Survey

DRAWBACKS OF THE EXISTING SYSTEM	METHODS FOR ERADICATING THE INVASIVES
Multiple Unmanned Aerialdrones cannot look under rubble.	Land based robots are used to overcome this invasives
Type 2 Fuzzy Logic Controllers were used for location, which resulted in high computation time.	Beacon technology is implemented in the proposed system which comparatively takes less computational time.
Multiple robots require high amount computation in coordination	The lack for need of communication until the last moment lowered need for coordination, thus less coordination is necessary

5. Tables, Figures and Equations

HUMAN DETECTION

Human Detection is the main part of each unit which enables it to locate victim.

Use of Detection algorithms

The detection of humans are done by OpenCv Haar Cascade methods

1.1.1 Face Detection is done by datasets compiled by OpenCv's haar cascade algorithms.[1]

Tested datasets

Various pre trained datasets were used in the prototype

Table. 2 Implementation Database Details

srno.	dataset details	
	Table column subhead	***images****
1	BioID Face Detection Database	1521
2	INRIA person dataset	12180

*Values are approximate

The accuracy of the system was highly dependent on the quality of the datasets.[2]

Hardware

Wireless cameras and light sources are provided in each unit to make the search possible.

Challenges

The accuracy of the system greatly depends on the accuracy of the detection dataset and lighting conditions. The way to overcome the lighting is that the system has its own light sources, and the accuracy is improved with more trained systems.

LOCATION TRACKING

The location tracking process of the whole system is very relative. This is done as setting up a system is hard in an Uneven playing field. However a setup point at any known stationary position solves the problem immediately of a relative position.

Calculation goals

The sensors in the system are mainly designed to find out the distance between the systems. Thus it will give us in sense the distance between 3 points in a triangle. The location is found by various formulas in the process.

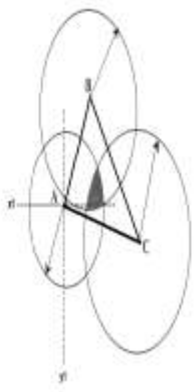

Fig. 2. approximate overlap of distances

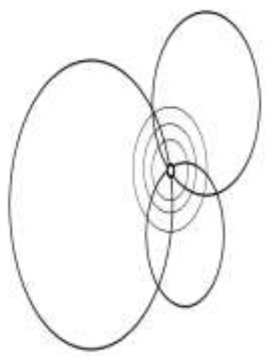

Fig.3 location tracking via approximate location

The sensors will find a relative location based on the distances from 3 other units to the 3rd unit. The 3 distances are taken as radii of 3 circles and the point of intersection is found as shown in figure 4. **This relative nature can be overcome by keeping 3 standing beacons with known coordinates on the field**

If the distances are not accurate enough to define a point of intersection, as per figure 3, the midpoint of a triangle given by joining the center of each circle is given, thus an approximate area of search is acquired.

Calculations
case of intersection

The two possible intersection points are found by comparing the two equations of the 1st two circles. with radii r1,r2 and centers (X1,Y1), (X2,Y2)

equation of circle is given by

$$(x-x_i)^2+(y-y_i)^2=r_i^2$$

equation of circle 1

$$x^2-2xx_1+x_1^2+y^2-2yy_1+y_1^2=r_1^2$$

equation of circle 2

$$x^2-2xx_2+x_2^2+y^2-2yy_2+y_2^2=r_2^2$$

then the two possible points are matched with the third circle with radii r3 and center (X3,Y3)

case of no common point

$$[(x_1 + x_2 + x_3)/3, (y_1 + y_2 + y_3)/3]$$

where Xi,Yi are the centers of each circle, hence the location of each unit

Signalling

Due their simplistic nature, beacons and beacon technology were the prime contenders for the signalling system. Sonar for distance detection is also considered viable sensor option.[3]

The HC-SR04 sonar detector was used in the prototype of this system[4], along with the cc2500 transceiver was used for communications.[5]

Challenges

The measured distances can vary from the actual distances, this causes the need for case of no common point to be calculated.

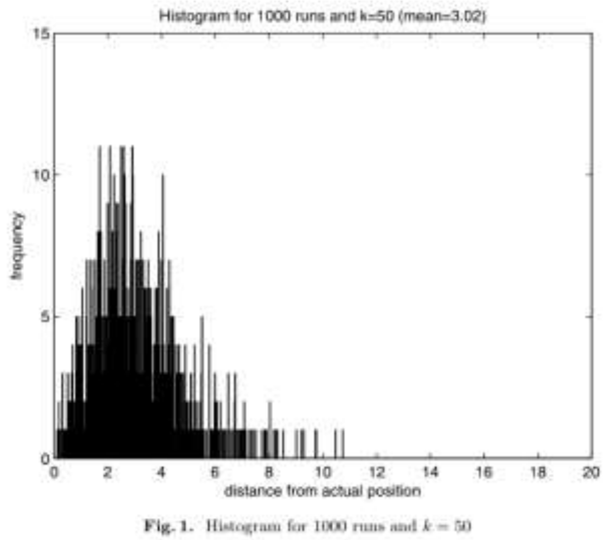

Fig. 4 . inaccuracy of distance calculation

Also depending on the terrain various systems can need to use various signalling systems. Thus beacons and sonar might need other helping hands.

MOVEMENT OF UNITS

Each unit is designed after a swarm robot, hence to allow it to move in a land terrain. Various previously made swarm models have been taken as the base for this along with the movement of various insects.
One of the already created bots that serve as a inspiration for this model is the already existing s-bot

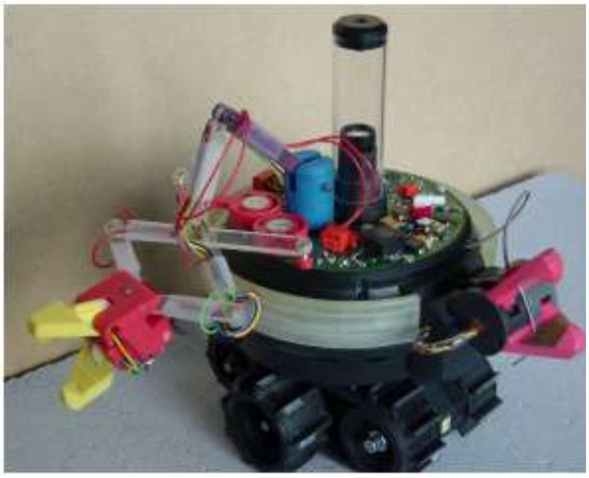

Fig. 5 S-bot prototype (an already existing swarm bot)

It is easier to use swarm based prototype robots as the unit carriers as they are already designed to communicate and move along terrains in small units, thus making them the suitable carrier concept.

6. Conclusions

The system is a swarm based system which has various payloads added to it to allow it to become a search bot. The main challenges in the system is the accuracy of detection for distances. The accuracy of each search would ideally approve with more tests.

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