# Research on Visualized Rescue Robot

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**Abstract**

Aimed at the shortcomings of the low efficiency and the limitation of the search and rescue robot, this paper presents a visualized search and rescue robot based on Arduino platform. The infrared detector for searching human body is used to detect lives, and the camera can transmit the information back to the mobile phone or computer terminal in real-time. The track wheel improves the capability of shuttle and over obstacle, and can easily cope with complex terrain. The mounded manipulator can complete many missions, such as clean up the road block and deliver essential supplies to small space. It can replace humans to carry out the task into the dangerous environment and search-and-rescue person into the confined space.

*Keywords*: visualized, Arduino, track, search-and-rescue

## 1. Introduction

With the rapid development of science and technology, the application of search and rescue robots become wider [1]. By virtue of superior mobility and well adapt ability in various environments, search and rescue robot have already been paid more and more attention. The search and rescue robot is experiencing rapid development, such as earthquake rescue robots, it is a robot used to search for survivors in the rubble of the underground shopping mall after the earthquake, which is equipped with a color camera, thermography and communication system [2]. The robot can replace the rescue workers into the dangerous environment, then implement the rescue work and transport the necessary supplies for the trapped persons. Therefore, it is important to develop a rescue robot that can replace or partially replace the relief workers into the unknown environment [3].

Search and rescue robot is different from the household robot or industrial robot. Its working environment is uncertain or serious. So we have higher requirements for the robot. Search and rescue robots generally have the following advantages [4-5]:

1. Walking through the ruins to detect signs of life freely with small size and flexible operation.

2. Having strong adaptability in various environment, which can arrive at the high temperature and high pressure place where the rescue workers cannot arrive in.

3. Being equipped with other functional sensors and detection equipment, such as infrared detector for human body and cameras.

4. Using lithium-ion batteries with low power consumption and strong battery life, so it can work for a long time.

## 2. Research at home and abroad

Since 1980s, the concept of search and rescue robot has been put forward, then, it gradually plays an irreplaceable role in the rescue activities. The study of search and rescue robots has several stages. One

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landmark event is the explosion of the Federal Building in Alfred, Oklahoma in 1995.It is the first time that the search and rescue robots appeared in public [6]. In 2001, 911 event, which is a case of search and rescue robot actual maneuver. The following agencies to participate in the rescue activities: The SOLEM system in Foster-Milker, the VGTV system in Tolon and the Microtac system in Inuktun. At the same time, many problems of search and rescue robots are exposed, including the choice of the control strategy and the problem of water proofness [7].

Since the 911 event, countries step up the pace of research on the rescue robots and set off a new wave of research. Then, research on search and rescue robots have a huge leap. Not only in theoretical and practical aspects, people have made big progress, but also published a lot of research results. And in appearance, functionality and performance, robots are becoming more and more perfect. Then, with the development of the technology and science, the crawler robots, snake-like robots and spider-shaped robots have been appeared.

Owing to the frequent earthquake and tsunami, Japan's search and rescue robot has been at the forefront of the world [8]. The Japanese spider-shaped robot, by mimicking the spider's movement, the multiple foots are coordinate with each other to complete a variety of actions, or jump over the obstacles. Better than crawler robots or snake-like robots, spider-shaped robots has a greater ability to adapt to the complex environment and to through the narrow space. In a word, it can quickly and efficiently complete the search and rescue mission. The "Asterisk" was developed by Professor Nii Kenzo at the Osaka University in Japan [9]. Not only the Asterisk's six foots can move on different ground, but also can it be used as a hand to move on the ceiling. Thus, it has a good prospect in the future.

Because of the complexity and the unknown environment, the robot must have better performance. And in order to better completing the search and rescue work, it should have an outside perception, by which it can work fine and transmit the current information in real-time with harsh environment. Therefore, this paper on the basis of studying both at home and abroad, then combined with the advantages and disadvantages of the practical application, we studied a new visualized rescue robot that has a greater ability to adapt to the complex environment and more powerful rescue capability [10].

## 3. The overall scheme design of search and rescue robots

Firstly, search and rescue robots enter the rescue scene. Second, gathering the information of the environment. Finally, using the camera to transmit images to mobile phone or computer terminal in real-time by wireless technology. Not only the search and rescue robots should have the ability of adapting to changeable environment, but also need the following functions:

- Collecting parameters in spot environment:

Search and rescue robots arrive at the accident scene to implement missions, which requires robots gathering information accurately and efficiently. The main functions are as follows: capturing motion video, infrared detector for human body and information transmission in real-time.

- Excellent overstepping capability:

Overstepping capability is an important index for search and rescue robot. When a rescue robot encounters obstacles, it can clear obstacles by mechanical arm. If the obstacle is big, it can also cross with a mechanical arm as main origin of force.

- Feedback capability in real-time

Visualization is a major feature of rescue robots, which can send the location information back to the outside world. Therefore, relief workers can get environment information and physical condition of the trapped personnel in real-time. In a word, it can provide more valuable information for the rescuer.

The overall scheme design of search and rescue robots as shown in the Fig.1:

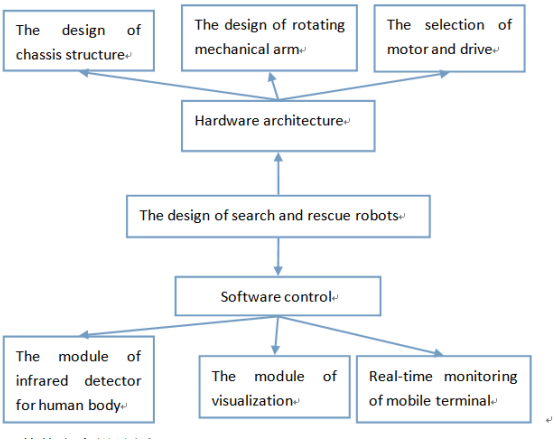


Fig.1 The overall scheme design of search and rescue robots

## 4. Design of mechanical structure

The mechanical structure design of search and rescue robots includes the design of the car chassis and the design of the manipulator. In the mechanical design process, the main part is car chassis, which determines maneuvering capability and it is important for overstepping obstacles.

Through analyzing the rescue robot chassis, we can conclude that the design is turned up, in the front of the car tracks, with an oblique angle (as shown in Fig 2.), this design can greatly enhance the ability to climb obstacles.

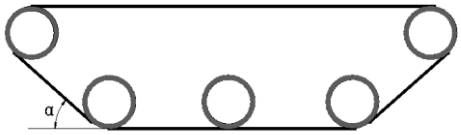


Fig 2. Crawler design of search and rescue robot

The design uses a rhombus frame structure. At the same time，the material selected guarantees the frame's strength as well as lower weight. Thus, in the main bearing part, installing reinforced steel plate to enhance strength. The height of overcoming obstacles is determined by the position of the robot's center of gravity and the length of the track, therefore, we lengthen the length of the track in the design of crawler structure and using symmetrical structure in the design of car body. The crawler mechanical structure has many advantages, such as gripping firmly, improving the ability of climbing and having good ability to overcome obstacles.

## 5. The circuit control unit

Circuit control unit includes the following sections： main control chip，driving motor, sensing scheme and remote signal transmission module. The sensing scheme includes a variety of sensing modules. For example, rotating machine arm function module, visual operation function module and the human infrared sensor module for detecting life characteristics. Finally, all these modules consist function platform of search and rescue robots.

### 5.1. *Main control chip*

The control circuit choose the ATmega128-AU as the main chip, which is used to control and deal with a variety of information from sensors. Its voltage is 3.3-5 V and it has 16M high speed crystal. At the same time, which can provide a high clock frequency. The main control chip have a high processing speed, so it can process the data from sensors more timely and more quickly.

ATmega128 in ATMEL is a CMOS 8 bit microcontroller based on the AVR with low power and high performance. The structure of the AVR is the Harvard, with independent data and program bus.ATmega128 contains EEPROM of 4K bytes, which can meet the needs of the program. The EEPROM as a separate department of data space, which reads and writes processes in bytes. At the same time, the EEPROM's life is at least 100000 times. The point of ATmega128 SCM and main control chips shown in the Fig 3.

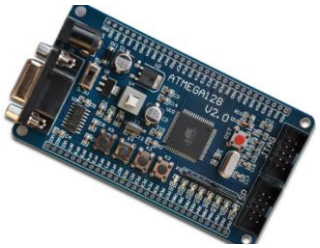

Fig 3. Main control chip

### 5.2. *Motor selection*

The motor provides power for the whole search and rescue robot. Through the motor mutual cooperation, it can complete a variety of different actions. As for motor selection, large torque motor can provide enough power in the progress of moving ahead. Therefore, the robot use 37GB-500 permanent-magnet direct current speed reduction motor, which rated voltage of 1.5-36 V ,rated speed of 5-3000 (rpm) and rated torque of 0.02-30 (NM).

Fig 4. DC geared motor

## 6. Introduction of functional modules

The sensor parameter gathering and human detection are very important aspects in the field of search and rescue robot. With a variety of auxiliary function modules, search and rescue robot can detect the location information and life characteristics of the trapped personnel, by which the rescue work can complete in real time. The data-collection of a single sensor is limited, so that it only gets partial environment information and does not let rescue workers get enough information of the trapped people. Thus, integrating multiple sensors into one piece instead of a single sensor, which has several advantages: enhancing detecting precision, reducing the costs of getting information, improving the intelligence level of search and rescue robots and completing the task in the shortest time.

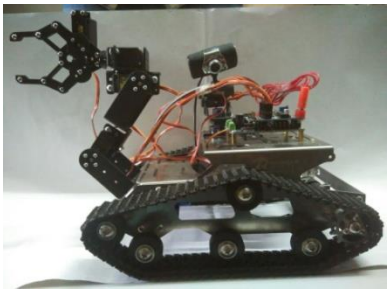

Fig 5. The overall structure figure

### 6.1. *The module of infrared detector for human body*

The visualized rescue robot can search and rescue trapped person in dangerous areas or in ruins, therefore, it need to carry the module of infrared detector for human body. In nature, all the objects will appear the phenomenon of infrared spectrum, so long as its absolute temperature exceeds -273℃.Such as: human body, stones, mountains, etc. But they have different wavelengths in the infrared spectrum. According to this natural phenomenon, it can be applied to the search and rescue work. From other sources: Normal body temperature is 36~37℃ and human body products wavelength of infrared spectrum is 9~10μm. Thus, in the rescue, pyroelectric infrared detector can be used to shorten the search and rescue time and increase the efficiency of search and rescue.

Pyroelectric effect is a polarization phenomenon that pyroelectric crystal will changes with the change of temperature. When the external alternating infrared radiation shines on pyroelectric crystal, the temperature of the crystal surface will have a significant change, so a strong external electric field is formed. Instead, when the external alternating infrared radiation does not shine on pyroelectric crystal, the temperature of the crystal surface will not have a significant change, so a strong external electric field is not formed. The characteristic of pyroelectric crystal can be applied to detect alternating infrared, but cannot detect the constant infrared. Pyroelectric crystal is generally produce electrical charge, so it needs to be converted into voltage and then put into use. Pyroelectric infrared sensors can detect whether the life exists, because the thickness of the filter is generally 14 ~ 8 m, it can cover the body's infrared. Thus, the sensors of infrared detector for human body achieve the effect, detecting human infrared. The sensors of infrared detector for human body as shown in the Fig 6.

Fig 6. The sensors of infrared detector for human body

### 6.2. *Rotating mechanical arm*

Search and rescue robot has a six-degree of freedom Rotating mechanical arm, which is an important part for search and rescue robot. When a small obstacle is in front of the robot, it can easily pass it by the rotating mechanical arm. If the obstacle is too big, the mechanical arm helps the crawler to climb. Thus, it has a stronger adaptability in complex environment. The rotating mechanical arm is made up of upper arm, lower arm and rotary frame. Upper arm and lower arm are mounted on the rotating frame by two large torque servo to drive, which has enough strength to carry goods. And when the lower arm moves, there's no need for additional arm operation, handling or cleaning operation can be controlled by a mechanical linkage firmware. The advantage of it is vastly simplifying operational. And the rotating frame is a support part of the whole mechanical arm system, on one side of it is equipped

with a high torque servo for rotating run the entire system.

Some parameters of the rotating mechanical are as follows: The rotating angle can reach on 180 degrees, the gyration radius is 355mm, the maximum height is 460mm (the gripper closed), the maximum of the opening in front of the gripper is 55mm and the widest range of the clipped goods is 98mm.Rotating mechanical arm is shown in the Fig.7.

Fig 7. Rotating mechanical arm

### 6.3. *The function of visualization*

Search and rescue robot has a function of visualization. In the upper part of the robot was equipped with two small geared motors that control the camera to move up and down or left and right, which is a major video capture device. The function of visualization is the primary mean to providing the environment information for rescuer in real-time, which we can see the importance of it. The situation of collapsed may be in poor light, thus, using lights may cause secondary damage to the affected people. In order to avoid this situation, the infrared camera is been selected, which with the function of wireless transmission. The model of the camera is SP-H01W (as shown in Fig 8), which wide-angle is 3.6mm and effective distance is 10m.And it has video recording function, which provides valuable data for the disaster relief.

The camera has the following features:

(1) The module of wireless transmission optimizes the H.264 lossless compression arithmetic, this method can decrease the transmission data and time in effect, which ensures high picture quality.

(2) With infrared light, the camera automatically switches between modes of day and night by the IR-CUT. In this way, it can guarantee the accuracy and clarity in the image transmission when the disaster scene is in poor light.

(3) The camera have the TF card slot in which video and image information can be saved in the rescue and relief operations. Therefore, it is convenient to optimize path in the progress of follow-up succor.

(4) The visual angle rotates 360 degrees and the camera rotates 80 degrees to ensure video capture in narrow space.

Fig 8. Video camera

## 7. The realization of the overall function

### 7.1. *Selection of rescue route*

Since we have finished the construction of Hardware and software platform of search and rescue robot, the last step is to process information from the robot and plan the path to reach to the scene. The information processing style is based on fuzzy reasoning, at the same time, the path planning based on the combination of artificial potential field method and grid method. Ultimately, through the test and analysis of the test results, it can be improved that the search and rescue robot is feasible.

Grid method has some disadvantages. First, the intensity of dividing the grip is difficult to control. Then, in order to accurately represent the location of the robots and obstacles, a large amount of storage space is occupied by much smaller grid granularity. But on the contrary, if the grid size is too large, it will make the robot path planning very inaccurate.

The artificial potential field method raised by Khatibis a virtual method, its basic idea is that we consider the motion of the robot in surrounding environment as a motion in a artificial gravitational field. The target point exerts a gravitational pull, on the contrary, the obstacle exerts repulsion to the mobile

robot. Finally, the movement of the mobile robot is controlled by the resultant force. In the process of search and rescue, to avoid crashing into obstacles and to approach the target gradually, the method is generally smooth and safe. But at the same time, the method has a defect of locally optimum.

The problem of path planning based on the combination of artificial potential field method and grid method. It is obvious that the two can learn from each other. Not only solving the problem of path planning inaccurately caused by grid granularity dividing, but also can we find the exact target coordinates by the artificial potential field method.

### 7.2. *Testing*

By the test of the search and rescue robot, the following data is obtained. The maximum height of the barrier crossing is 120 mm, the maximum angle of climbing is 38, the maximum range of detection is a circle of radius 1, and the maximum distance of transmission is 22m. Through the above analysis of the data, which can basically meet the needs of rescue.

## 8. Conclusion

On the basis of analyzing current robot, a kind of visualized rescue robot was designed. The robot has more perfect functions better than current rescue robot. On the one hand, the design of walking manner is based on the crawler structure with an oblique angle, and cooperate with rotating mechanical arm, which improve the ability of climbing. On the other hand, using camera and the technology of wireless transmission to transmit the image information to the control terminal in real-time. At the same time, with the sensors of infrared detector for human body, the rescue robot can detect the affected person on a wide range, through these functions, the search and rescue robot can achieve timely rescue. In the design, the final step is test, which include the ability of climbing, the accuracy of infrared detector for human body and the relationship between wireless transmission distance and obstacle. Finally, the test result shows that the visualized search and rescue robot have a good ability to overcome obstacles and can basically meet the needs of rescue.

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