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Nasser Halabi, Graduate Student, Damascus University, Syrian Arab Republic
Mhd. Eid Qusaybatie, Master Degree Student, Damascus University, Syrian Arab Republic
Rayed Homsi, Graduate Student, Damascus University, Syrian Arab Republic
Mhd. Aiman Al Akkad, Dr. Eng., Damascus University, Syrian Arab Republic

DESIGNING AND IMPLEMENTING A ROBOTIC RANGER TO SCAN ROUGH TERRAINS

Finding a suitable design to scanning rough terrains have always been an aim for designers. Therefore in this paper different methods used for this purpose are shown, and our robotic vehicle Rubian for exploring irregular areas is suggested. The implementation of this design is shown, and the conclusion about the ability of our robot to handle sophisticated tasks is drawn.

Key words: robotic vehicle, mobile robot, irregular areas exploration, autonomous robot, obstacles detection and avoidance, robot navigation.

Landmines are considered to be a major problem facing both humanitarian and economical development in many parts of the world.

With the absence of landmines' maps the threat is becoming even bigger especially in countries such as Lebanon and Afghanistan which have suffered civil wars.

In addition to the huge cost of demining and human resources needed to execute this process, arise the dangers to the humans who are responsible of detecting and neutralizing landmines.

Researchers worldwide are working to develop methods to both detect and neutralize landmines autonomously in order to both minimize risk to humans and speed up the process. In this quest, different architectures for these robots were suggested each having its pros and cons [1, 2, 3, 4, 5].

This paper summarizes the design and implantation of a robotic ranger to scan rough terrains autonomously.

Most autonomous robots used in landmines detection require a continuous remote control by humans to guide the robot through the required area [6, 7]. Therefore we chose an architecture that allows a full automatic mode to operate, giving the ranger the ability to scan the required field without continuous human supervision.

Design Considerations

In a rough terrain environment, it’s very important to have the ability to skip edged rocks, climb step-like natural obstacles and rotate the robot in a fixed position (tank turning maneuver).

After studying several architectures with each having its advantages and disadvantages, we found that a Rubian like architecture would best suit the requirements of this ranger, allowing it to operate in a full automatic mode.

In a regular architecture with classic bogies on sides, rangers face trouble crossing over edged objects, whereas the Rubian architecture avoids this problem with its parallel bogies which enables the ranger to cross over an object up to 3 times its wheel diameter as shown in figure 1. The front fork represents an additional advantage for this architecture, allowing the ranger to climb step-like natural obstacles.

This design requires paying attention to the following:

– A full automatic movement mode in rough terrains would require a very accurate straight line movement.

– The idea of full automatic mode would require smart and efficient power consumption in a battery powered robot.

– Due to some manufacturing mistakes, the scanning algorithm has to be modified to minimize some structural defects.

– In a rough terrain, large obstacles represent a major problem; an obstacle avoidance algorithm has to be implemented.

Figure 1. The Rubian structure allows avoiding the problems due to crossing over edged objects.

Implementation Outline

Here we will not discuss the mechanical components in detail instead we will concentrate on the control part of this design:

Embedded system

The ranger’s embedded system is responsible for gathering the sensors’ signals, processing the incoming data from sensors and PC, and the control of motors. Therefore it is a multi-microcontroller system dealing with 62 input/output channels. This embedded system is considered to be a large scale system represented by hi-

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erarchical model as shown in figure 2. Where the sensors and motors are in the low level layer, the cell controllers are in the middle layer and the main controller which is the coordinator is in the high level layer. Microcontrollers' modules are connected to an I^2C network giving the system the ability to add new modules for future development without modifying the original modules.

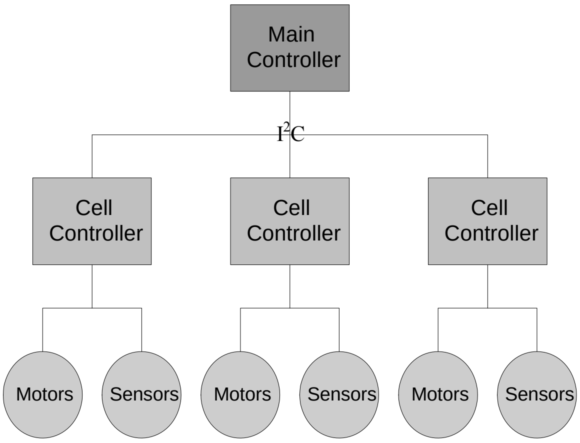

Figure 2. The embedded system hierarchical model

Power supply

In a battery powered system it is very important to have both power stability and measurable power consumption in order to achieve an accurate movement and give the robot the ability to predict the point of no-return especially in a demining application. Therefore the ranger can specify the point of no-return and return to its start point with the shortest path possible. The power supply is divided into three modules, one for the embedded system, another is for the sensors and the last one is for the motors and metal detector board.

Movement algorithm

The movement algorithm is designed in a way that partial sectors of the dangerous area could be secured without the need to wait for the whole area to be scanned; the area is divided into equal square-shaped sectors with the ranger moving from one sector to another as shown in figure 3. The scanning lines are overlapped for more accuracy. Due to manufacturing defects, the movement algorithm had to be modified into “every other line” scanning mode to overcome some weaknesses in the mechanical structure which could lead to the breaking of the bogies joints in case of severe side torques when the ranger makes a 180° turn. A full automatic mode would require an obstacle avoidance technique which is implemented with the help of infrared sensors. Another important thing for the full automatic mode is the straight line movement ability which required a wheels' level measurement method using infrared encoders.

Experimental results

The experiments which we've carried out were based on moving the robot over a plane irregular field where the height of obstacles is about 12 cm. When the height of obstacle in comparison with the dimensions of the robot exceeds this threshold the performance will be unsuitable.

Besides to achieve good results and precision in the movement of the robot we had to correct the regular and irregular errors, and we've compared the results with those of classical structures.

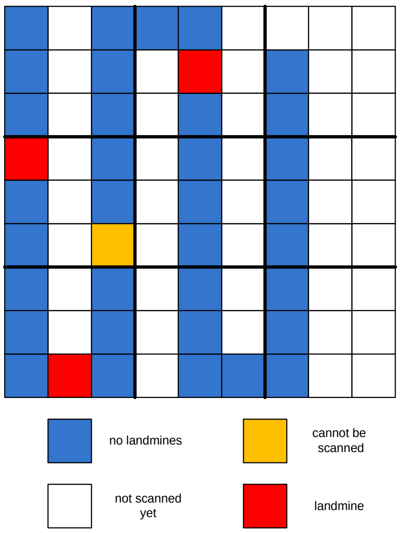

Figure 3. A snapshot of the robot interface software showing the scanning of the squared sectors, step1

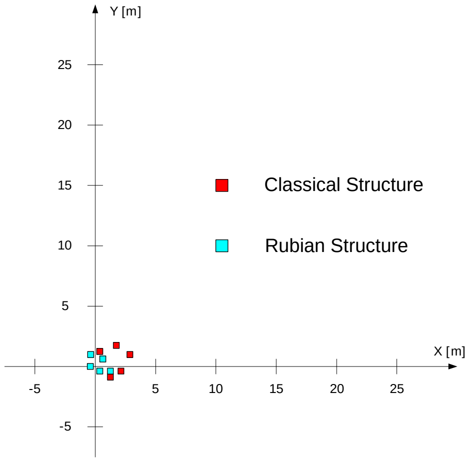

Figure 4. A comparison between the results of the classical structure and Rubian structure in case of returning to zero

Conclusion

The structure of our robotic vehicle allows it to have excellent maneuvering capabilities for exploring irregular terrain areas in comparison with other designs.

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Насер Халяби, аспирант, Дамасский университет, Сирийская Арабская Республика
Мхд. Эйд Кусайбати, магистрант, Дамасский университет, Сирийская Арабская Республика
Райед Хомси, инженер, аспирант, Дамасский университет, Сирийская Арабская Республика
Мхд. Айман Аль Аккад, кандидат технических наук, Дамасский университет, Сирийская Арабская Республика

Проектирование и разработка роботизированного локатора для сканирования пересеченной местности

Задачей конструкторов всегда был поиск подходящей конструкции для сканирования пересеченной местности. Рассматриваются различные способы достижения этой цели. Для исследования пересеченной местности предлагается использовать разработанный авторами мобильный робот Rubian. Описывается его конструкция и дается заключение о способности робота выполнять сложные задачи.

Ключевые слова: транспортные роботы, мобильные роботы, исследование пересеченной местности, обнаружение и обход препятствий, навигация робота.

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О. В. Малина, доктор технических наук, доцент, Ижевский государственный технический университет имени М. Т. Калашникова
О. Ф. Валеев, аспирант, Ижевский государственный технический университет имени М. Т. Калашникова
С. А. Морозов, кандидат технических наук, доцент, Ижевский государственный технический университет имени М. Т. Калашникова
А. В. Холмогоров, магистрант, Ижевский государственный технический университет имени М. Т. Калашникова

ПОДХОДЫ К ОРГАНИЗАЦИИ ЭКСПЕРТНОГО ОПРОСА ПОДСИСТЕМЫ ФОРМИРОВАНИЯ КЛАССИФИКАТОРА СИСТЕМЫ СТРУКТУРНОГО СИНТЕЗА КОНЕЧНЫХ ОБЪЕКТОВ, ПОСТРОЕННЫХ НА ДИСКРЕТНЫХ СТРУКТУРАХ

Рассматриваются подходы к организации экспертного опроса, позволяющие снять жесткие ограничения на представление структуры объекта, уменьшить избыточность модели класса объектов, максимально автоматизировать процесс формирования классификатора – информационной базы системы синтеза.

Ключевые слова: экспертный опрос, декомпозиция структуры объекта, графовая модель, характеризационный признак, автоматизация синтеза классификатора.

Одним из походов к структурному синтезу объектов, построенных на дискретных структурах, является оптимизированный комбинаторный перебор. В качестве множества элементов для реализации перебора предлагается множество значений признаков классификатора, описывающего множество рассматриваемых объектов. Рассмотрение указанного множества оправдано вследствие того, что именно классификатор объединяет в себе знания о возможных альтернативах конструктивного решения отдельных деталей, узлов, модулей и изделия в целом.

Рассмотрим алгоритм формирования классификатора.

1. Описание известных конструктивных решений и представление их в виде графов типа дерево $G(V, E)$, где V – множество функциональных элементов объекта (структурообразующих модулей) и множество характеристик (модулей, обеспечивающих структурную полноту); E – множество связей, демонстрирующих соподчиненность функциональных элементов и принадлежность характеристик функциональным элементам [1].

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