# Development of Contact Interaction-based Navigation of Mobile Robots

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**Abstract**

In the field of robots? obstacle avoidance and navigation, indirect contact sensors such as visual, ultrasonic and infrared detection are widely used. A variety of sensor systems of varying ability have been proposed and successfully used to address the problem. However, different environments, such as the dark, dense fog, underwater conditions, always influence the performance of these sensors. This paper probes the lower limits of this range by describing an extremely simple robot with which navigation is still possible. We develop a mechanism based on the navigation strategy of interactive information relative position of the objects contacted or its own position information would be obtained through contact information of its own arm. A navigation method for a mobile robot is introduced based on it. More precisely, it presents a navigation method for a robot equipped with a 1-DOF antenna as an end effector. In this context, the interaction information between mobile robot and wall comes from the robot end effector. Finally, the feasibility and reliability of this study are verified by the simulation results.
**Keywords**: Modeling, Optimization , Contact interaction based Navigation, mobile robots

## 1 Introduction

The main task of a mobile robot is to perform navigation and orientation. We mainly consider the navigation problem that deals with moving a robot to a destination. Of course, to accomplish the tasks, a robot has to have a sophisticated sensor system, durable mechanic structure and highly developed computing system. Navigation varies greatly with the sensory system of the robot. Sensory systems are usually based on Light waves such as IR and laser, Sound wave such as ultrasound, electromagnetics wave and vision based such as image processing systems or kinect. In normal conditions, it is obvious that a navigation system that applies non-contact sensors provides intensive information about the environment [1]. However, robots cannot just rely on this type of sensing information to effectively work and cooperate with humans. For example, light condition is necessary for the visual navigation Moreover vision sensors have significant measurement accuracy problems resulting from technical problems

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such as low camera. In addition to the above, a laser range finder is impractical to embed in a robot system because of its size and weight [2].Also Magnetic navigation holds in a certain area and cannot complete simple obstacle-avoidance action.
Due to the failure in the robot sensors inn real applications , the robots are likely to be required to operate in harsh environments whose visibility is very low, such as in a dark room , dense fog, underwater or during a rescue mission at an earthquake site where movement and internal calculations may have inaccuracies. [3]. Effective robots must, in some way, be robust to errors in precision and accuracy. A navigation system that applies contact-based sensors is capable of solving the above mentioned problems that is to say it can do a good remedy for the existing independent navigation under an unknown environment. Furthermore, the system architecture is simpler and can easily be mounted on the mobile robot body. However, in order to effectively navigate robot locomotion based on this type of sensing information, it is necessary to develop a reliable navigation strategy in the robot control system. Designing complex robots with more sensor sets and actuators has the advantage of careful algorithm designing and programming, then an alternative approach has been suggested in which these difficulties are dealt with by designing extremely simple robots to complete their assigned tasks. The whole of this approach has been called ?minimalist robotics?. Much attention has been given to the problem of localization for robots with varying degrees of sensing capability. In industrial settings, more complex tasks can be solved by sequences of these simple robots [4,5]. It has long been known that robot designs with simplified sensing and actuation models can lead to decreased costs and increased robustness.
In robotics, it is believed the more the system is inspired by a natural species the better it accomplishs a similar task. The dynamics of task accomplishment of the natural system have been captured by designers to re-create a qualitatively similar set of dynamics in the artificial system. Whiskers that are widespread in many natural species, for short-range navigation and exploration .Rats for example can use them for local navigation, for exploration of objects [6] and for discrimination of different surface textures [7].Whisker technologies have been developed by Russell [8] as well as instrumented antennae by Lee et al. [9] and Lamperski et al. [10]. To sense tactile forces, Liljeback et al. [11,12] embedded sensors into the joint modules of snake robots to improve locomotion. A robotic system performing a navigation task must have the ability to move itself from an initial position to a desired one. Basically, the navigation system encompasses such subcomponents as sensing, localization, obstacle avoidance, path planning and path execution. Most reports are related to applications involving mobile robots and humanoids on a static platform [1]. Moreover, only a small number of achievements are reported relating to navigation applying contact-based sensors. Most reports are related to perception-guided navigation, dealing particularly with visual-based navigation and application of a laser range sensor. Related with navigation strategy in a robot system, several approaches such as a mapping strategy [13], application of collision prediction functions [14] and on-line learning strategy [15] are been used. However, in this research, we would like to focus in motion trajectory generation in mobile robot based on contact interaction information of the robot arm(antenna) with objects.
This paper applies this idea to the problem of navigation in an attempt to describe

the simplest possible robot. In addition, it is of basic scientific interest to explore the minimum sensing requirements for robotic tasks. We propose a robot model in which only a map and contact information are available. Odometry, range sensing abilities are omitted. With such a robot, the only reliable courses of action are to select a motion direction and move in that direction as far as possible.

# 2 Problem statement

## 2.1 Robot Model

This study uses a differential drive robot. The considered model has two identical wheels, positioned in the same axis, moving only around that, independently controlled by motors. The rolling of the wheels is considered pure, so that there are no sideslips during movement. It is assumed that the center of mass is located in its geometric center and hence eliminating possible unbalances accelerations Coriolis and centrifugal effects. The linear speed of the robot can be described on average function of linear velocities of right and left wheels .

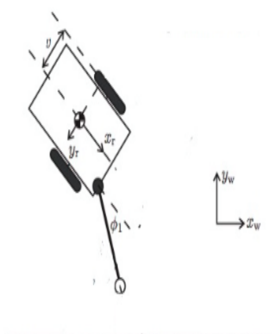

**Figure 1**-Model of a mobile robot with antenna

## 2.2 Methods

The mobile robot can complete the tasks such as detecting, self-positions and navigation, local planning of location paths, which is not affected by light and air quality. we can easily change the behavior of the robot by developing our own algorithms from the ground up with the emphasis of mimicking human arm movements. To mimic human movement we need to mount proper mechanical sensors to record position and velocity and force (or torque) applied to antenna or robot link beside link?s actuator. Selecting the method of processing measured values and collected data for the purpose of navigating robot to find the exit door out of environment are the problems of this project.
Therefore a method of mobile robot navigation is introduced with the goal is to find the relative position of robot with respect to walls and more specifically find the exit door. A robot, equipped with a cane .In the absence of odometry, the only reliable actions

for the robot are maximal linear motions. That is, the robot can select a direction and to move reliably in that direction as far as the environment allows.

# 3 Strategy of the interactive information navigation

One of the core research contents of this project is to calculate correctly position and posture of the robot according to the wall. Through the motion parameters of robot and contact angle information between end effecter and walls, we can calculate its current pose information.
The a) Searching Tasks to find objects is performed in sequences. During the searching process, the motion will stop when the arm touches an object and the angle detected exceeds the desired angle value. At this current stage, object detection is limited to a wall with a flat surface whose height is bigger than the robot. b) Self-Localization Tasks also it is important for the robot to at first recognize its position and orientation within the environment in which it operates before performing the navigation tasks. This process is called self-localization. In our proposed navigation strategy, self-localization is performed by touching wall?s surface to define its orientation and confirms its presence. Based on this information, the relative relations of the robot and the object can be defined. c) Correction of Locomotion Direction Tasks consists of the correction of distance and angle. When touching a wall, correction of the robot?s distance was simply performed by arm deviation that involves trajectory generation of robot in contact with the object. However, to prevent the probability of collision, it will move backward. d) Finding the exit door Basically, finding wall is performed first by correcting the robot?s distance and before proceeding to the correct angle. However, if no wall has been detected, the robot will continue to correct its angle. The robot will rotate its orientation to face the wall to confirm its position. The robot?s arm will repeat the process of confirming the wall?s presence until the wall is no longer detected. Once this happens, the robot will move forward and complete the process of confirming the door.

# 4 Robot control

The control for the robot consists of a reflex behavior. By default, it moves forward with constant speed. If, the antenna is stimulated above threshold, the robot drives backwards. For every time-step we consider whether antenna is stimulated or not. These parameters are chosen heuristically, such that the robot shows acceptable navigation. If the robot does not get stuck, the run terminated after some cycles. We will show, for different tasks and with a simple controller, that the performance can be significantly enhanced with an appropriate morphology where the sensory space matches the physical space that the agent occupies.

# 5 Simulation Results

Simulation is important to prove the validity of the method. It is expected that the proposed algorithms for mobile robot navigation strategy based on moving its arm effectively operate in unknown environments and leads to better self localization in order to make the robot recognize its surrounding in environments.
During navigation,the robot recorded the random position of itself, arm position and wall positions and so on in real-time. If the arm did not detect the presence of wall then the robot would determine the scope of the safety and move toward the wall steadily in that range. If the arm detected the presence of arm then the robot would move along the wall until pass the wall and find the door.
The efficiency of the robot's motion is closely related with the chosen path, the better path have been chosenthe higher efficiency would be obtained, but it does not mean that the higher efficiency, the better. Blindly to improve efficiency may lead to movement distance farther.

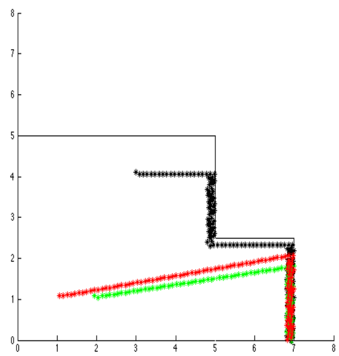


**Figure 2**-The motion trails of the robot with arm

# 6 Discussion

In tis paper, we analyzed the robot?s locomotion functions based on contact interaction of the robot antenna with objects. Without its contact information, the robot cannot draw any conclusions about the results of its actions. We develop a basic interaction-based navigation strategy for mobile robots capable of performing self-localization and wall following tasks. The proposed navigation strategy required that four main tasks be solved: searching tasks, self-localization, and correction of locomotion direction and find the exit door. This system is based on the contact interaction of the robot antenna with objects. Our goal is to create suitable algorithms for mobile robots to effectively operate in environments where visual information is not available. Its aim is to complete the survey, self-localization and the path programming, and it is a good supplement to existing navigation methods such as the image, light, electromagnetism, sound. It provides convenience to human daily life, and provides great help in rescue and relief. Taking the contact-based navigation robot as the research object, the model and algorithm of navigation are studied in this research.

By increasing the reliability of the model and algorithm, the robot can complete the obstacle avoidance task under any map navigation with higher stability. However, we have left open a number of interesting questions.

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