AIN SHAMS UNIVERSITY

FACULTY OF ENGINEERING

Mechatronics Engineering

Using Task Redundancy for Obstacle Avoidance in Robot Navigation

A Thesis submitted in partial fulfillment of the requirements of the degree of

Master of Science in Mechanical Engineering

(Mechatronics Engineering)

by

Hend Mohamed Hafez Abdel-Dayem

Bachelor of Science in Mechanical Engineering

(Mechatronics Engineering)

High institute of Engineering, 6-October City, 2008

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Statement

This thesis is submitted as a partial fulfilment of Master of Science in Mechanical Engineering, Faculty of Engineering, Ain shams University.

The author carried out the work included in this thesis, and no part of it has been submitted for a degree or a qualification at any other scientific entity.

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ABSTRACT

The goal is to apply vision based robot control by exploring the information provided by vision sensor in feedback control loop. This visual based controller is used to control the motion of designed four wheels mobile robot in unstructured indoor environment. Tasks performed by the robot required the robot to move from initial position toward a desired position while keeping the object in the field of view of the camera with the capability to avoid collision with front obstacles encountered during its motion.

A mobile robot is designed with suitable dimensions and load capabilities to be able to carry a laptop and a holder for a camera. The designed robot is a four wheeled having one motor for each wheel and equipped with two infrared proximity reflection switch sensors to be able to avoid front obstacles during its mission and equipped also with Microsoft Kinect camera to track the target and give the feedback signal to the robot controller.

In order to achieve this goal, LabVIEW software is used to implement a vision-based controller which consists of the integration of three sub-systems, vision subsystem, PID controller subsystem, and avoidance subsystem. Vision and avoidance subsystem send their feedback signal to the controller subsystem to correct the errors in the robot motion. This vision based controller allows the robot to perform visual navigation and follow target object. The vision- based controller system with obstacle avoidance has been investigated experimentally using the designed four wheeled mobile robot.

Keywords: Vision-based control –Mobile robot –LabVIEW software – Microsoft Kinect camera– Obstacle avoidance.

SUMMARY

Visual sense is one of the most significant human senses that provide sufficient information and non-contact measurements from unknown environment. Using visual information allows avoiding various kind of failure in the robot task. These failures may result from errors due to wheel slip, environment structure and imprecise modelling concerning the kinematics of robot. These errors lead eventually to error in robot position. To avoid this kind of failures visual information is used in closed loop robot control.

Vision based control is an important method which is composed of many subsystems including vision subsystem, robot subsystem and controller subsystem all are combined together to give the vision based robot system. This robot system is able to operate in an unknown environment by using some measurements of the visual information in a feedback control loop to manage the movement of the robot from the initial position toward the target object in the desired position.

In vision-based controller the set of feature points defining the object is extracted from the acquired image. These extracted set of features is tracked by the vision subsystem during the motion of the robot. Also the current set of image features and the desired set of image features are used to define the error signal which presents the input signals to the controller of mobile robot.

The designed control system is used to control the robot motion to reach the target position by ensuring that the object is in the field of view of the camera while avoiding any obstacles during the motion. The general control scheme is thus a combination of two control tasks named main and secondary tasks. The main

task considers the vision based motion control toward the target object. Microsoft Kinect camera is used as visual sensor for navigation. Generally, this camera helps to extract the depth features of targets thanks to RGB-D tracking system. While the secondary task considers the IR sensor based motion control to avoid the encountered obstacles during the performing of the main task. Infrared Reflection switch sensor is used for obstacle avoidance which measures the IR light that is transmitted by an IR LED in the environment to detect objects. This type of sensor is popular in navigation for object avoidance.

To accomplish this work, theoretical studies of robot kinematics, vision systems, and closed loop robot controller were very important. After studying these subjects the robot system is designed and constructed. A closed vision based control scheme is designed and implemented for controlling the robot motion. The designed vision based mobile robot occupied with a Kinect camera for tracking objects and IR sensor for obstacle avoidance is tested in a real environment.

The aim of the main task is to move the robot to the desired position which is ensured by minimizing the error between the two sets of current and desired features. But, moving the mobile robot has to consider avoiding obstacles while performing the main task that is why, in this work the available redundancy of the main task is used to consider the secondary task (avoidance task). This ensures that the robot will reach the desired position as well as it’s possible to consider the avoidance task in the redundant space of the main task.

In order to design the robot, the dimensions and the weights carried by the robot are determined and the suitable material is chosen. The robot has two main parts; the main body part carrying and containing hardware components including Motors, Motor Driver, Encoders, an embedded hardware device called myRIO and

Battery; the upper layer part which carry the laptop, the sensors and the camera with its holder.

LabVIEW is chosen as a programming language to apply vision-based control and avoidance tasks to the robot platform. All controller programs discussed in this work including PID controller, Kinect based-controller, infrared based controller and the general controller are implemented and tested.

The Kinect based-controller is tested to show how it controls the movement of the robot with different conditions of the planned task. Whether the target image is directly in the front of the robot or shifted to the right or to the left sides. The results of these experiments are given which show the trajectory of the robot and its velocity.

Infrared based controller is also tested to see how the robot can sense and avoid any obstacle in its way. Three experiments are executed to consider three different cases, case one: When no obstacles are considered, case two: when the obstacle is in the left hand side of the robot, case three: when the obstacle is in the right hand side of the robot.

Finally, the combination of the two controller systems is tested which allows the robot to avoid obstacles while moving toward the target object. All the results showed that the controller system allows the mobile robot to perform the task in a good and effective manner. All experiments are performed in Faculty of computer and Information sciences, Ain Shams University.

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