A Goal Oriented Navigation System Using Vision

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***Abstract*—This paper addresses a goal oriented navigation framework in a behavior-based manner for autonomous systems. The framework is mainly designed based on a behavioral architecture and relies on a monocular vision camera to obtain the location of goal. The framework employs a virtual physic based method to steer the robot towards the goal while avoiding unknown obstacles, located along its path. Simulation results validate the performance of the proposed framework.**

***Index Terms*—Goal-Oriented Navigation; Mobile Robots; Monocular Vision; Behavioral Design.**

I. Introduction

Over recent years, there has been an explosive growth of interest in using vision for goal oriented systems in mobile robot navigation. Most of the goal oriented systems utilize metric or topological maps of the environment to navigate, providing the exact knowledge of the environment [1], [2]. Vision is mainly integrated into goal oriented systems either to recognize landmarks or goals observed in an image. For landmark based systems, localization is essential, which includes four steps, namely image acquisition, landmark detection, matching and calculate position. Details of these steps and can be seen in [3]. Besides, there are methods to be able to detect landmarks on the 2-D image, and track them in the consecutive scenes. Landmarks can be artificial or natural. In both cases, the robot needs to recognize the landmarks in order to be able to track them [4]. A good example of natural landmark tracking-based navigation can be seen in [5].

Vision based robot navigation systems that do not require a metric or topological map are called as mapless navigation systems which are able to navigate by extracting relevant information about the landmarks in the environment. Optical flow is one of the main methodologies used for vision based mapless navigation problem. Optical flow is considered as a 2D vector field describing the apparent motion of each pixel in successive images in a 3-D scene [6]. Several optical flow based navigation strategies using more than one camera have been introduced by researchers; biologically inspired behaviors, based on stereo vision have been adapted for obstacle avoidance. Despite their simplicity, optical flow based navigation systems are mainly designed for vision based obstacle avoidance problem and are sensitive to lighting conditions of the environment. Alternatively, appearance-based methods are employed to navigate robots. The main idea lies behind these methods to store images of the working environment and associate these images with commands to navigate the robot towards a final goal [7], [8]. Feature based methods are also widely used in the corresponding field that the trajectory and motion of the robot is primarily determined by matching the features of reference and the current images during the navigation task [9], [10].

Conventional AI approaches in robotics are limited due to their computational complexity. Alternatively, Behavioral robotics has gathered lots of attention from the researchers, interested in the field. This concept is inspired by the idea that the intelligence has to be studied in terms of a robot interacting with its environment. According to this approach, the navigation task is divided into multiple independent task-achieving modules or behavior [11]. These modules are responsible for a subtask of the whole action. The Subsumption Architecture is a milestone in the control of behavior-based robotics which mainly decomposes complicated behaviors into many primitive behavior modules. Each layer implements a particular goal and subsumes that of the underlying layers [11]. This paper proposes a simple but efficient vision based goal-oriented navigation framework for mobile robot navigation problem.

The framework proposed in this paper is designed based on a behavioral architecture and employs a vision-based goal recognition system. The vision system mainly aims to detect the goal and estimate its distance to the goal. Once the goal is determined, the robot is steered towards the goal using a virtual physic based method in which the goal is associated with attractive forces and the obstacles or other robots are repulsive forces [12]. The main advantage of this method is smoothly converts the entire sensory input space into actuators space without requiring extra rule. This paper is organized as follows. In Section 2, the design of the behavior-based mobile robot system is presented. Section 3 provides the implementation of the behavior-based robot and the experiment results from simulation. The study is concluded in Section 4.

II. Goal-Oriented Navigation Framework

This section introduces the proposed goal-oriented framework that the flowchart of the system is illustrated in Figure 1. According to the which, the system primarily searches for the goal with a random walking behavior; once the goal is found the distance estimation module determines the distance and absolute location of the goal. Those position data are passed to the behavioral architecture so as to steer the robot towards a predefined goal safely and efficiently.

A. Goal Estimation

This section addresses the goal estimation methodology used by the proposed framework. A vision based approach, employing an appearance based methodology is adapted, is integrated into the framework. The corresponding algorithm is given in Figure 2.