Chapter 40
Assistive Intelligent Humanoid Robot in Human Environment

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ABSTRACT

The number of robots operating in human environments is increasing every day. In order to operate in such environments, the robot must be able to navigate, interact with human, pick and place different objects. This chapter presents a mobile humanoid robot that is able to localize itself, navigate to the target location, and generates the arm motion based on the specific task. The robot utilizes the Laser Range Finder, camera and compass sensor for localization and navigation. In addition, the robot generates the arm motion satisfying multiple motion criteria, simultaneously. This chapter evolves neural controllers that generate the humanoid robot arm motion in dynamic environment optimizing three different objective functions: minimum time, distance and acceleration. In a single ran of Multi-Objective Genetic Algorithm, multiple neural controllers are generate and the same neural controller can be employed to generate the robot motion for a wide range of initial and goal positions.

INTRODUCTION

The need for assistive robotics is expected to grow due to the large number of elderly people and shortage of qualified staff, especially in developed countries. The assistive robots are divided mainly in two categories: 1) Rehabilitation robots and 2) Assistive social robots. The second one is further divided in 2 subcategories: a) Service robots and b) Companion robots.

This chapter focuses on service robots which are mainly used to assist elderly or unable people in everyday life activities. The authors present a humanoid robot mobile platform that is able to self localizes, navigate to the target location, and perform picking and placing tasks using both arms. In performing domestics task such as cleaning, picking and carrying food or household item from one room to another, a mobile humanoid robot are required to have high mobility, and ability to manipulate object in opti-

mized manner. There are numbers of constraints and consideration need to be made in order to perform these tasks such as unknown environment, obstacles avoidance, object recognition and manipulation, the execution time, safety features and understanding human instruction.

In order to perform a navigation task such as getting a bottle of juice from the kitchen or guiding humans to the desired location, numbers of considerations need to be made such as understanding the command, determining the environment, obstacles avoidance, object recognition and manipulation and human safety. Chen & Kemp (2011; 2010) has proposed a direct contact between human and robot to guide the human from one location to another, for example leading a child by the hand or assisting nurses in hospitals. A direct physical interface is introduced to enables a user to influence the robot behavior by making contact to the robot body. Testing has been done in a real hospital with volunteered nurses to test the performance of the robot. In their work, a combination of MEKA Robotic arms, an Omni directional Segway and a linear actuator by Festo are used as complete robotic system. The robot wrist is equipped with six axis force sensor to sense the input from human, while holding their hand. A nurse robot, PEARL has been presented in (Pollack et al., 2002) for assisting the elderly. Two main purpose of PEARL is to remind people about routine activities such eating, drinking, bathing and taking medicine and the other function is to guide them through their environment.

In (Stuckler et al., 2009), a personal robot for helping household chores has been presented. The robot called "Dynamaid" adapted four schemes for navigation namely Fast Simultaneously Localization and Mapping (FastSLAM), localization, path planning and safe local navigation. Holz et al. (Holz, Nieuwenhuisen, & Droeschel, 2013), has proposed global-to-local control strategy to navigate the developed robot, Cosero from the transport box to the processing place for bin picking. Adaptive Monte Carlo Localization is used to estimate the robot's pose in a given grid map using LRF. A* search is applied to find the shortest obstacles free path from the estimate position to the target location. For the arm manipulation, LBKPIECE is utilized in order to maximized the performance and reduce the execution time.

During everyday task performance, humans move their arms in different ways satisfying different constraints. For example to move a cup of coffee, human arm need to move such as to minimize the acceleration in order not to spill the coffee. For more complicated tasks such as drawing a straight line or pushing a non-rigid object, the kinematics constraints such as velocity and acceleration are required to be decreased resulting in a longer execution time. Such scenarios inspired researchers to adapt the similar approach in generating robot hand motion for specific tasks.

Many different methods and approaches have been proposed in the past decades on humanoid robot arm motion generation. A minimum time trajectories robot arm motion has been proposed in (Sahar & Hollerbach, 1986). In their work, a general solution is proposed to solve minimum time trajectory path which involves joint space tessellation, a dynamic time scaling and a graph search. The full dynamics of the arm movement and actuator constraints are incorporated. With these features, the arm motion while avoiding obstacle can be easily generated. Flash & Hogans (1985) had proposed minimum hand jerk criteria where the position vector of the hand is defined with respect to the Cartesian coordinate system. Differentiating the position three times will define the jerk of the hand. The arm motion from its initial to the goal position is generated by minimizing the time integral of the square magnitude of jerk. Rosenbaum et al. (1995) has proposed a similar approach of generating arm motion by minimum angle jerk. The coordinate movement of the arm and trunk using optimization criteria defined in the joint space.

Minimum torque change criterion has been introduced by Uno et al. (1989), where control objects are the joint links plan in an intrinsic dynamic-mechanical space. The hand trajectory properties are

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