Abstract

One of the well-known algorithms to build path planning is Artificial Potential Field (APF). APF has two advantages: it can be run with real time obstacle avoidance and can be well implemented with low level control. Although APF is very effective but several problems still arise due to local minima, Goal Non Reachable Obstacle Nearby (GNRON) problem, limited usage with local information, and non-holonomic constraints. Local minima and GNRON problems affect the static movement of the robot so that the robot will not meet the goal point. In addition, non-holonomic constraints consider the kinematic constraint of the robot. Consequently, neglecting kinematic constraint makes the APF merely applied for holonomic robot. Without the ability of local information handling, the robot must obtain a prior environment knowledge. Thus, this dissertation has three contributions. The first contribution is development of APF to cope the local minima and GNRON problems. The second contribution handles kinematic constraint in non-holonomic mobile robot since APF merely assumes the robot is a point mass. Finally, the last contribution is the use of local information on APF.

A simple idea on how to handle non-holonomic constraints is to convert the equilibrium point on the kinematic control as the position for the APF. Thus, the states of the kinematic control become dynamic and the direction of the APF is used to control the angular velocity. For the local minima and GNRON problems, consideration of surrounding repulsive forces gives a trigger to escape from the local minima and the additional signum function on the repulsive force which considers relative distance between the robot and goal ensures that the goal position is the global optima of the total potential. An approach to handle the local information in the APF uses the integration of the image processing, clustering, and framework transformation. The initial, goal, and obstacles from the real world coordinate can be determined in the APF environment scenario by using the proposed method.

By combining with the APF, the kinematic control is able to avoid the obstacle besides the ability to adapt with non-holonomic constraint. The results show that the equilibrium point of the kinematic control adapts to the APF with 91.67% probability of success. The failure condition has been found in the size of $6.4x6.4m^2$. Using mathematical analysis, stability and convergence can be achieved by the control system. In the local minima and GNRON problems, the results have been verified that the proposed algorithm solves the local minima and GNRON problems with 100 percent of success for both collinear and noncollinear condition. Local information that is acquired by camera and laser sensor can be well applied using the integration method. The results show the robot avoids either static or dynamic environment and reaches the goal position.

Keywords: APF, Local Minima, GNRON, Nonholonomic Constraints, Kinematic Control, Local Information