Performance comparison of various navigation guidance methods in interception of a moving object by a serial manipulator considering its kinematic and dynamic limits

Mohammad Keshmiri
Isfahan University of Technology
Dynamic and Robotic Center
Isfahan, Iran
m.keshmiri@me.iut.ac.ir

Mehdi Keshmiri
Isfahan University of Technology
Dynamic and Robotic Center
Isfahan, Iran
mehdik@cc.iut.ac.ir

***Abstract*— In this paper a comparative analysis is represented on various navigation guidance methods used for intercepting fast maneuvering moving objects. A glancing revision is introduced on relevant works within the introduction section. Four common methods for navigation guidance known as PNG, APNG, IPNG and AIPNG are under investigation. Results demonstrate their infirmity on smoothly intercepting a moving object. Hence, to improve the navigation guidance methods and to adapt them with robotic problems a modified version of AIPNG is proposed for 2D problems and is developed for 3D problems utilization.**

I. INTRODUCTION

Interception of a moving object can be discussed in two different classes based on the objects' velocity[1];

1. Object with slow maneuvering motion,
2. Object with fast maneuvering motion.

A slow maneuvering motion is usually known as a constant velocity or a motion with small acceleration magnitudes. Therefore, a reliable anticipation can be derived on the objects motion and furthermore time optimal methods can be presented for object interception[2, 3]. Unlike slow maneuvering objects, during a fast maneuvering motion, abrupt trajectory variation occurs frequently and as a result practical predictions are impossible.

In another point of view catching a moving object using a serial manipulator can be classified to four categories as follow:

3. Trajectory regeneration methods
4. Navigation Guidance methods
5. Visual servoing methods
6. Potential field methods

Considering the first class, systems are constituted of a separate trajectory planning section. This section plans the desired path considering the robot position and objects predicted position. The desired trajectory will be regenerated continuously for the new conditions. These methods are known as Prediction, Planning and Execution methods (PPE or APPE) and are suitably functional in case of objects with slow maneuverability [4].

A widely used method for intercepting fast-maneuvering moving objects falls under the category of navigation and guidance theory. Navigation-based techniques were originally developed for the control of missiles tracking free-flying targets. In these methods the strategy of interception is expressed as closing the interceptor and objects distance and guiding the object to a collision course with the target by enforcing an acceleration vector to the interceptor. Accelerator magnitude and direction is computed based on the objects velocity and position vectors [4, 5].

Visual servoing methods, however, do not possess any trajectory planning section. The controller block attempts to eliminate the velocity and position error between the interceptor and the target utilizing prevalent control schemes. Because of their computational efficiency, such methods are well suited for tracking fast-maneuvering objects[6, 7]. Vision systems are commonly used as feedback sensors in order to produce essential environmental information.

Fourth category is called the potential field method and is enumerated as a common method in catching objects in presence of obstacles[8].

Navigation Guidance Based Interception

This method has been used for tracking of free flying objects through last 5 decades. The most important application for this method is guiding missile to aim another free flying objects like airplanes or rockets.

Several navigation guidance laws are presented until now. PNG is the most common law that has been well analyzed and evaluated recently [9, 10]. Widespread researches present PNG as a time-optimal solution for intercepting object with constant velocity. In [11-13], it is demonstrated that PNG method loses the quality of being time-optimal, in case of objects evading with a accelerating

978-1-4244-7826-2/10/$26.00 ©2010 IEEE