Chapter 12
Using Physics Inspired Wave Agents in a Virtual Environment:
Longitudinal Distance Control in Robots Platoon

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ABSTRACT

The monitoring and the surveillance of industrial and agricultural sites have become first order tasks mainly for security or the safety reasons. The main issues of this activity is tied to the size of the sites and to their accessibility. Thus, it seems nowadays relevant to tackle with this problem with robots, which can detect potential issues with a low operational cost. To that purpose, in addition to individual patrolling behavior, robots need coordination schemes. The goal of this paper is to explore the possibility of using interference fringes and waves properties in a virtual environment to tackle with the longitudinal distance regulation in the platoon control issue. The proposed model, based on a multi-agent paradigm, is considering each vehicle as an agent wave generator in the virtual environment.

DOI: 10.4018/978-1-7998-0951-7.ch012

1. INTRODUCTION

The monitoring and the surveillance of industrial and agricultural sites have become first order tasks for several reasons such as the security or the safety. For agricultural sites, the monitoring can also be used to adapt the feeding in fertilizer and the prevention of the expansion of diseases. The main issues of this activity is tied to the size of the sites and to their accessibility. Thus, it seems nowadays relevant to tackle with this problem with robots (wheeled or aerial) which can detect potential issues with a low operational cost.

To that purpose, in addition to individual patrolling behavior, robots need coordination schemes and strategies for surrounding a target or for moving collectively as a platoon to one specific location. Among these coordination schemes, platoon control algorithms are mostly used especially when one want to coordinate vehicles. Platoon control has become a wide spread research area for collective robot control but also for autonomous vehicles. A platoon system can be defined as a set of vehicles that move together without any material coupling while maintaining a specific geometric configuration that can be a column, a line, a diagonal or any combination of these. A lot of research projects have been dealing with platoon control for robots moves synchronization or vehicles on highways (Path (\cite{shladover2007path}), SARTRE European project[1]), in urban areas (SafePlatoon[2]) or for freight transportation (FurBot[3]). The column configuration (robots one behind another) is the most spread in literature even if other spatial configurations can also be useful such as in military or agricultural contexts for harvesting for instance.

Basically, there are two main trends for performing platoon control depending on whether the localization reference frame is local (tied to the robot we want to control) or global (common to all the robots of the platoon). In the global approaches, the reference frame can be a shared predefined trajectory, or the trajectory of the leader of the formation sent directly to all its mates. This approach relies on specific methods and sensors aimed at precisely determining each robots position relatively to the global reference frame. Besides, in the case of a transmission of the trajectory of one specific robot in run time, each of them must have efficient and reliable wireless communication devices. The global point is the most spread in literature (Guillet, Lenain, Thuilot, & Martinet, 2014), (Bom, Thuilot, Marmoiton, & Martinet, 2005), (Avanzini, Thuilot, & Martinet, Manual convoying of automated urban vehicles relying on monocular vision, 2012), (Avanzini, Royer, Thuilot, & Derutin, 2013).

On the other side, the local approaches are based on a reference frame local to each robot of the platoon. Thus, each of them is only capable of following one of the robots perceived in its neighborhood, which is thus considered as its local leader. For instance, in a column configuration (i.e. vehicle forming a row), the local leader is generally taken as the preceding robot in the row. Among the papers found in literature based on this approach, one can cite: (El-Zaher, Gechter, Gruer, & Hajjar, 2011), (Scheuer, Simonin, & Charpillet, 2009), (Bouchaala, Marouf, Abualhoul, Pollard, Shagdar, & Nashashibi, 2013), (Abualhoul, Marouf, Shagdar, & Nashashibi, 2013), (Dafflon, Gechter, Gruer, & Koukam, 2013), and (Yazbeck, Scheuer, & Charpillet, 2014).

Each of these solutions is linked to interesting properties. The local approaches are tied to a "individual" standpoint of the platoon function. Generally, they are more simple to put into practice but provide less precise results especially for lateral distance. However, some solutions (El zaher, Gechter, Hajjar, & Gruer, 2016), based on a virtual link with dynamic properties, can compensate this problem. By contrast, due to their "system" point of view, global approaches have better results but requires to design algorithms according to the specific required devices aimed at feeding them in data such as precise differential GPS, communication protocols...

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