Chapter 74
Visual Detection in Linked Multi-Component Robotic Systems

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ABSTRACT

In this chapter, a system to identify the different elements of a Linked Multi-Component Robotic System (L-MCRS) is specified, designed, and implemented. A L-MCRS is composed of several independent robots and a linking element between them which provide a greater complexity to these systems. The identification system is used to model each component of the L-MCRS using very basic information about each of the individual components. So, different state models that have been used in several works of the literature that have been reviewed can be covered. The chapter explains the design of the system and shows its frontend. This work is the first step towards a realistic implementation of L-MCRS.

INTRODUCTION

This chapter deals with the practical problem of parts identification and segmentation of the single elements that compose any instance of a Linked Multi-Component Robotic System (L-MCRS) (Duro, Graña, & de Lope, 2010). L-MRCS are composed of a number of mobile robotic elements that are linked by any flexible unidimensional element, and the interaction between the passive, flexible element and the robots introduces highly non-linear effects in the system's dynamics. As it is an open issue, we are interested in autonomous behavior learning in L-MRCS.

Several algorithms and techniques to achieve this objective have been tested and validated through computer simulations using accurate geometrical and dynamical models based on several computational tools, as it will be referenced

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later. Then, they have to be verified in real world systems to ensure that they maintain the expected performance under real world circumstances, ensuring this through several realistic experiments.

Each one of the elements which compose the L-MCRS is characterized by several attributes, and obtaining those object attributes of each element is relatively easy in the computer simulation environment. Once they have been obtained, other attributes that describe the relation between the mobile robots and the flexible element can be derived from them. To be able to reproduce the results obtained previously through computer simulations (Fernandez-Gauna, Lopez-Guede, Zulueta, & Graña, 2010), any kind of real-time perception system is required. We have addressed the possibility of doing this by means of a computer based vision system that fulfills several requirements, which will be exposed later. This vision system must give support to the decision algorithms that have been designed and trained assuming that they could know in any moment several relevant properties about the different elements of the L-MCRS.

The chapter is structured as follows: first, a background section introduces the L-MCRS. Later, a main section, where we describe the identification system is composed of several subsections devoted to its specifications, to the global pipeline and to a detailed explanation of the pipeline illustrated with several figures showing all process. Finally, we address future research directions and expose our conclusions.

BACKGROUND

In this section we are going to introduce the Linked Multi-Component Robotic Systems (L-MCRS) through a short review of the literature that shows several works that have been done up to now.

Linked Multi-Component Robotic Systems

Linked Multi-Component Robotic Systems (L-MCRS) are categorized by (Duro, Graña, & de Lope, 2010) as a collection of autonomous robots linked by a non-rigid physical link which must be modelled precisely because it is the source of strong non-linearities in the system dynamics. Multiple models proposed for uni-dimensional objects are reviewed in (Echegoyen, 2009) (Echegoyen, Villaverde, Moreno, Graña, & d'Anjou, 2010): differential equations (Pai, 2002), rigid element chains (Hergenrother & Dhne, 2000), spring mass systems (Gregoire, & Schomer, 2007), combinations of spline geometrical models and physical dynamical models (Qin, & Terzopoulos, 1996), and combinations of spline models and the Cosserat rod theory (Theetten, Grisoni, Andriot, & Barsky, 2008). We have done several computer simulations based on building our system dynamics model on a combination of spline models and the Cosserat rod theory to perform our simulations, because it improves the geometrical spline representation by adding force and torques (Antman, 1995) (Rubin, 2000) allowing to model the twisting of the hose. This approach, known as Geometrically Exact Dynamic Splines (GEDS), represents the control points of the splines by the three Cartesian coordinates plus a fourth coordinate representing the twisting state of the hose.

More recently, a new approach based on Reinforcement Learning (RL) (Sutton, & Barto, 1998) has been carried out by our group to learn autonomously behaviors because RL techniques have been used successfully in several areas of robotics. These areas are navigation (Duan, & Hexu, 2005), indoor navigation (Chen, Yang, Zhou, & Dong, 2008), cooperative navigation task (Melo, & Ribeiro, 2008) and automatic path search (Miyata, Nakamura, Yanou, & Takehara, 2009).

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