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Study of using deep learning nets for mark detection in space docking control images

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Abstract

There is a problem of understanding of relative position between two spacecrafts in process of docking. Use of images from camera set on spacecraft and observing another one is probably effective solution of this problem. Spacecraft position can be calculated using visual marks and knowledge of spatial configuration of observing spacecraft. Detection of visual marks is important part of this solution. Possibility of using deep networks for increase mark detection quality researched. Results of detection using various net architectures compared to current solution that uses improved Viola-Jones detector.

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Keywords: RCNN; deep learning; object detection; space docking control.

1. Introduction

1.1. Problem description

Detection of relative position of spacecrafts is a senior problem, especially for the rendezvous and docking stages of the spacecraft and the International Space Station (ISS). Nowadays, spacecrafts rendezvous and docking processed using special radio-electronic optical systems. Components of that systems must be installed on the International Space Station and on a spacecraft that shall be docked. Also during last 40 years every cargo and passenger spacecraft

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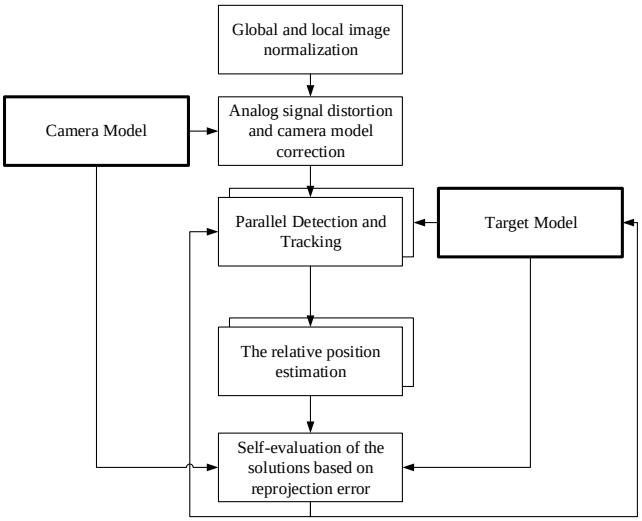

Fig. 1. Algorithm of relative 3D pose estimation.

is equipped with television systems, that allow ISS and spacecraft see each other. This television system is using during docking as a special visual control tool.

Earlier, in articles[1,2] the way of using this television system to detect the position of spacecraft relative to ISS was described. Special software that can be installed on special notebook inside ISS or on a desktop computer in the Mission Control Center was developed. This software receives video signal from the camera on a spacecraft and processes simultaneous detection and tracking of natural visible features on the ISS. Using this features position, known model of the TV camera and precision 3D model of the ISS, this software is able to calculate position of spacecraft relative to ISS very accurate by solving the PnP problem.

1.2. Description of current solution

In this section described current algorithm of solving problem of detection of relative position between spacecraft. Overall structure of current algorithm represented on the Fig. 1.

Camera model represents conditions between 3D points coordinates in the scene and the pixel coordinates in the 2D frame. Camera model is determining by camera calibration using special stand or chessboard template while spacecraft is on the ground, using methods, that described, for example, in the articles[3,4]. Also, if is needed, camera can be calibrated when spacecraft is already in space, by using images, that contains ISS. Images must contain at least 8 points with known 3D coordinates, than can be used methods, described in articles[5,6].

ISS precision 3D model contains information about relative position of the construction features, and also descriptors, using for detection of this features. Also there is some characteristics of current system, that construction feature points are combined to point sets (according to the distance between the spacecrafts, lighting conditions, active docking module, etc.).

Current object (feature points) detection algorithm using sliding window, statistically effective multi-scale block local binary patterns[7] (SEMB-LBP) as a descriptors, and also especially learned cascade classifier, more thoroughly described in articles[8,9,10].

When four or more features detected for one frame, PnP-problem can be calculated to evaluate full 3D spacecraft position relative to the ISS.