

NEWTON-TYPE METHODS FOR DETECTING ROBOTIC ARM POSITION USING CAMERA

Michaela Bailova⁽¹⁾, Petr Beremlijski⁽¹⁾, Michal Beres⁽²⁾

⁽¹⁾VSB - Technical University of Ostrava

⁽²⁾VSB - Technical University of Ostrava, Institute of Geonics of the Czech Academy of Sciences

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Abstract

This contribution introduces a digital twin of an industrial camera for the calibration of robotic manipulators in manufacturing processes. The core of the proposed approach is a digital twin using the full camera model to accurately approximate the camera's characteristics.

The main objective is to estimate the camera's location and orientation based on the captured image of the specially designed calibration pattern with five significant points. This task translates to an unconstrained quadratic programming problem, where the goal is to find a camera's pose, where the projection of the calibration points computed by the camera model is as close as possible to the captured image.

The most challenging aspect of the proposed approach is the highly nonlinear nature of the function being minimized. The situation is even more complicated by the presence of numerous local minima caused by noisy measurements on the camera's image. To get a solution suitable for an industrial application, it is necessary to find the global minimum in real time. This requires a quick, reliable method capable of finding the correct solution for any pose, regardless of the initial guess.

To solve this problem, we investigated and compared several optimization strategies. An integral part of such a solution is Newton's method, which exhibits fast (superlinear) convergence near the optimum. However, its performance depends strongly on the choice of the initial guess. Hence, it must be combined with a global minimization approach, forming a hybrid optimization technique.

The proposed framework is motivated by practical problems arising in industrial or real-world applications, where reliable and efficient calibration procedures are essential. The main advantage of the proposed approaches is their robustness and speed, so they can be used in real-time applications such as trajectory approximation.