CALIBRATION OF A ROBOT ARM USING LASER TRACKER MEASUREMENTS AND ARTIFICIAL NEURAL NETWORKS

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INTRODUCTION

Robot arms offer a high repeatability, which is for most tasks e.g. pick and place sufficient. However, if a precise absolute pose of the robot arm end-effector is questioned, a calibration is inevitable. The kinematics of such robot arm is well understood, however considering its mass or forces acting on it, can lead to a complex system. Generally, if the description of a system cannot be established on basis of physical models due to its complexity, Artificial Neural Networks (ANN) can be used. In this contribution an ANN is built calibrating the zero positions of the encoder. However, the aim is to include stochastics and physical information into the ANN. The estimation of the ANN in the extended Kalman Filter (EKF) enables the integration of stochastic information in the chosen approach.

EXPERIMENTS

The test object is an industrial 6-axis robot arm. A kinematic system description of the robot arm includes the encoder values and the arm lengths. In order to calibrate the robot arm, the absolute end-effector positions are measured by a laser tracker and the position error is used as an output in the ANN. To keep complexity of the ANN low and due to the reason that the zero position of the encoders is the main error source of absolute position errors of such a robot arm [1], the ANN input is only based on the encoder values. Consequently, the robot arm system consists of six encoder values as inputs and three position errors as outputs dx, dy, dz. The generated data set bases on 800 robot arm poses distributed in the working field. 600 positions are used for the training and 200 to test the generalization capability of the generated ANN, see Figure 1.

The weights of the ANN are estimated in the Extended Kalman Filter (EKF), which has been proposed by Singhal and Wu[2]. Thereby, the ANN serves as the observation equation and the system equation corresponds to a static model. The method consisting of ANN and EKF is compared to the standard ANN computation on basis of Levenberg-Marquardt (LM). The two methods are equal under specific assumptions. However, the estimation in the EKF offers some features[3].

The model selection task of determining the number of weights/knots in the hidden layer of the ANN has been accomplished by cross-validation.

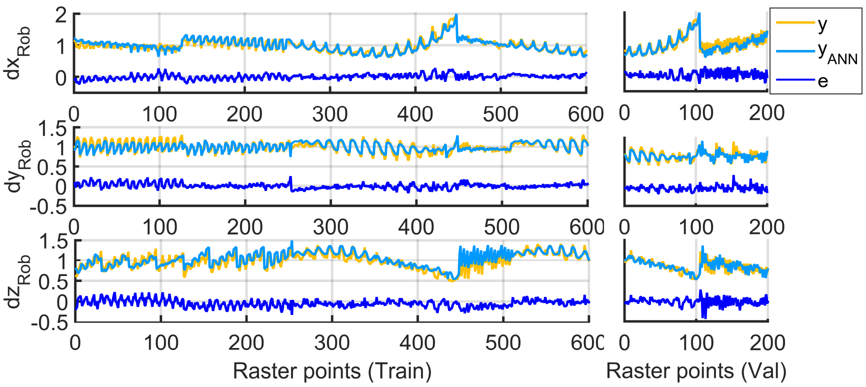

Figure 1: Position deviations in mm
(for a better visualisation y and y_{ANN} are shifted by +1)

RESULTS

An advantage of the proposed method has already been figured out in the model selection task, which needs 30 weights less in the hidden layer than the standard approach (LM). If less weights need to be determined, the number of observed robot arm poses can be reduced significantly. In Figure 1 the result with the best generalization capability is presented, which has been reached by only updating the covariance matrix of the weights. Furthermore, the updating step in the EKF leads to a faster convergence. Consequently, the chosen method offers some advantages.

CONCLUSION

This is a first approach to describe a kinematic robot arm system by ANNs. The stochastic information of the observed absolute position deviations is considered in the calibration of the encoder zero positions. In future the additional benefit of the EKF approach shall be figured out in more detail. The aim is to integrate knowledge of a system as e.g. a mechanical model in the presented approach.

REFERENCES

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