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ON-LINE CORRECTION OF ROBOTS PATH BASED ON COMPUTER VISION

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Abstract: *This paper presents the methodology for a real-time trajectory correction applied to industrial robots. The application is based on computer vision concerned with the line detection creating a trajectory for the robot motion. The algorithm for the line detection was developed in Matlab/Simulink computing software. The trajectory is corrected by a controller implemented in PLC Beckhoff that communicated with the robot controller via DeviceNet in real-time.*

Keywords: ***Computer vision, control, trajectory, PLC, real-time, industrial robot.***

1. Introduction

In industrial robotics there are applications where we need to correct a robot trajectory in real-time. It could be for example robotic welding. To connect two points by a seam, industrial robot interpolates the trajectory by a line. However many variables enter this process, such as the errors of pre-machining, in-process thermal distortions, which would cause changes of the seam position (Shen et al., 2010). Another variable is the accuracy of the robot movement. All of these variables will cause inaccurate placement of the seam and will affect the quality of the seam. That is why the robot path needs to be corrected by a sensory-based system.

Robots path is usually corrected by a controller. An important thing at any trajectory correction is to choose a controller and set it. A lot of previous researches have been done in the field of robot trajectory correction. Most of the previous works used the PID controller, for example Shen et al. (2010), Yilmaz & Sagiroglu (2009), Fang et al. (2010) or Xu et al. (2004). Fang et al. (2011) has done an experiment comparing the PID controller against a fuzzy controller which was improved by him (called self-tuning fuzzy controller). In this experiment he found out that the self-tuning fuzzy controller had better response to a large step disturbance than the PID controller. He described the self-tuning fuzzy controller to be more robust, steady and to have higher tracking accuracy than the PID controller in the case of trajectory correction.

2. Proposed solution

2.1. System description

The whole on-line trajectory correction system includes following parts: industrial camera Manta (Allied Vision Technologies), PLC Beckhoff, industrial robot KUKA and PC (Fig. 1 Photo of the workplace).

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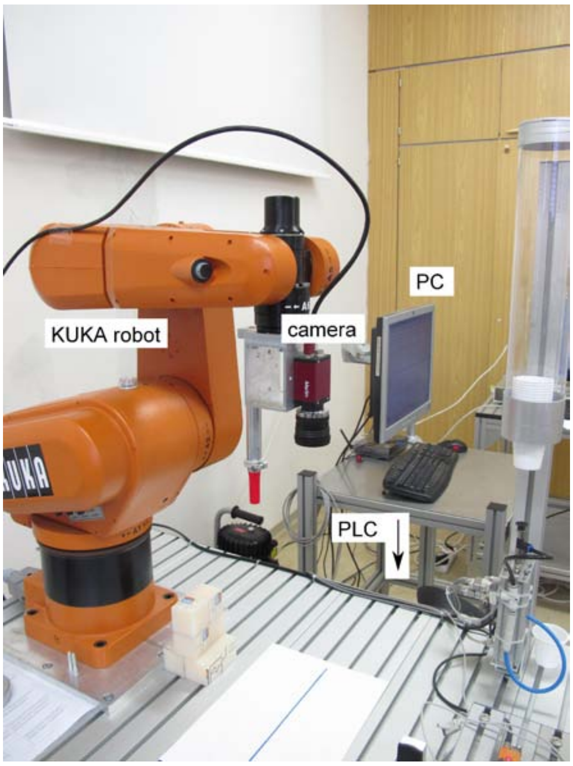

Fig. 1: Photo of the workplace

Processing starts in the industrial camera where an image is acquired. Then the image is processed in the Matlab software implemented in the PC. Processed data from the Matlab are then forwarded to the PLC where a PI controller is implemented influencing the robot´s movement (Fig. 2 Control loop, green arrows).

On the Fig. 2 there is also a communication loop (blue arrows). The industrial camera is connected to the PC by the FireWire. In the Matlab software there is implemented a TCP/IP client which instructs a TCP/IP server implemented in the PLC. PLC is connected with the robot controller via DeviceNet fieldbus in real-time. The PLC is also used as a main control of the whole task.

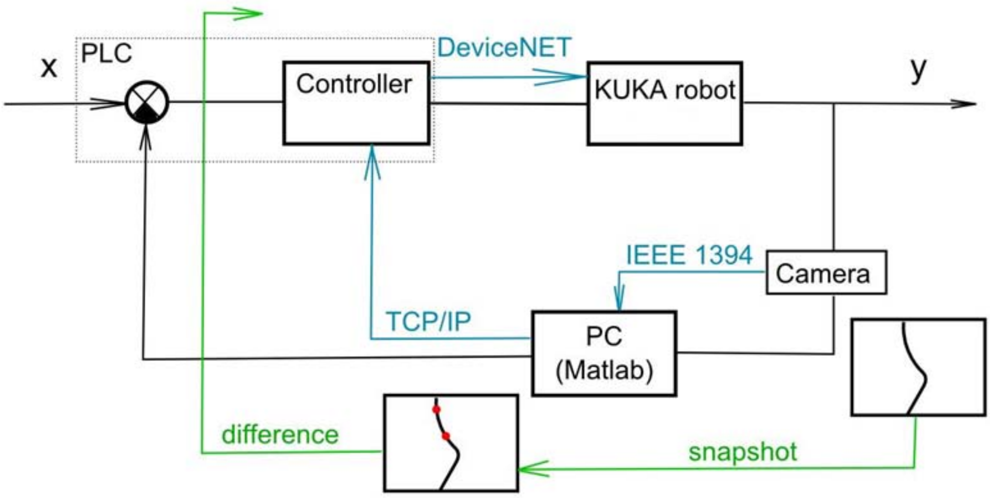

Fig. 2: Control loop

2.2. Detailed description

A simple image processing algorithm is programmed in the Matlab software. The algorithm is based on extraction a center of a line viewed through the camera. After the extraction the center is compared against the center of the camera´s field of view. The difference is then forwarded to the PI controller as the error.

2.3. Experiment result

An experiment was designed to test system accuracy to correct robot´s trajectory in an industrial application. The system accuracy could be tested by watching the difference by eyes between a certain drawn trajectory and the robot corrected trajectory. However watching the difference by eyes would not be accurate because we would not get exact information. For the purpose of extracting the number data, the experiment was designed as follows. First a sine curve trajectory was created by the robot. This trajectory was drawn by a fix mounted on the robot´s effector. During the drawing the trajectory points were recorded. Then the robot was moving along the created trajectory and tried to on-line correct the movement by the proposed system. Errors of proposed control system were recorded and both records were then compared against themselves (Fig. 3 Comparison of a drawn sine curve and the robot corrected trajectory).

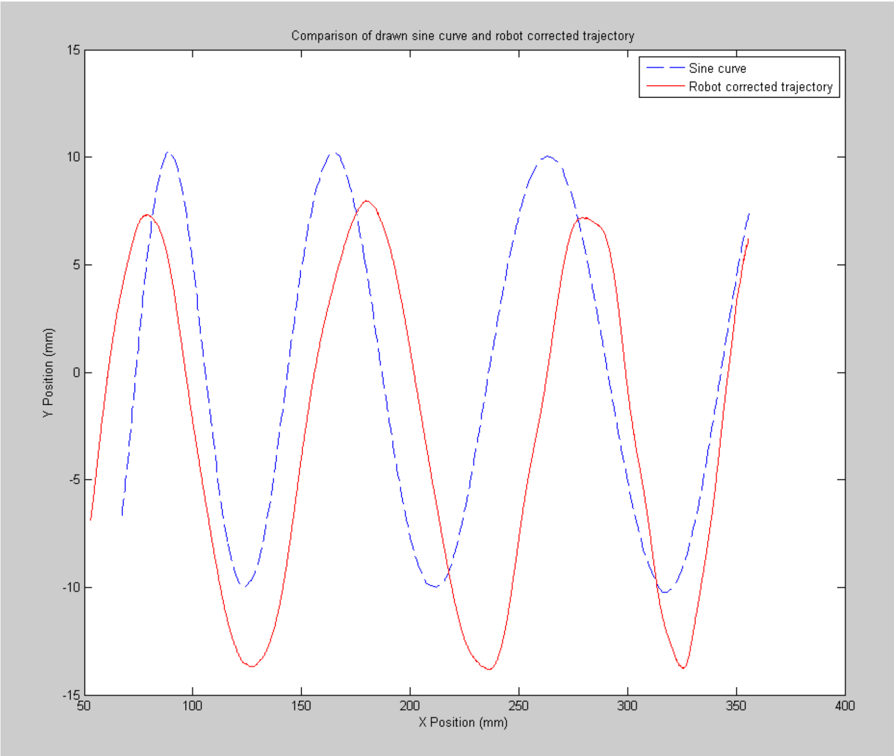

Fig. 3: Comparison of a drawn sine curve and the robot corrected trajectory

In this experiment the PI controller was implemented to influent the robot´s movement.

There has not been done any calibration of the camera in the sense of unification of the Cartesian coordinate system of the robot and the camera. For our testing purposes we needed only to recalculate the difference from pixel units to millimeters. To recalculate the difference from pixel units to millimeters we simply calculate the difference at a specific camera´s depth of focus in millimeters.

The cycle from acquiring image data to giving move instructions to the robot last about 20ms. The whole process could be faster but because of complex algorithm of TCP/IP communication we could not have a better processing time. Another thing is that we did not need better processing time in this pilot study.

3. Conclusions

An experiment has been done to correct the robot´s trajectory by a computer vision system. In the experiment a data from the image processing algorithm were send to the PI controller.

Most of image processing algorithms are light sensitive which cause low robustness of the algorithm and of course a lot of errors during the running application. Changes of light or creating shadows in the workplace caused a lot of errors in our experiment too. Problem of changing light conditions is still a developing area in computer vision. Therefore there will be an improvements concerning investigation of light influence on the image processing algorithm and there will be also some precautions leading to reduce the light influence. Another improvement of the image processing algorithm will be also focused on a correction of more complex-shaped trajectories, for example trajectories with step changes.

On the Fig. 3 is shown our experiment result. The robot trajectory was corrected only in the Y position. Errors between the drawn sine curve and the robot corrected movement along the sine curve are about 1 to 3 mm. Such a relatively high errors will be reduced towards zero in the next experiment prepared after this pilot study.

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