Visit Report

Visit start date: 05th January 2015
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Challenges:

- The aim of this project is to create a virtual model of two-dimensional robotic manipulator and universal, portable and hardware independent control system for visual position control of the manipulator utilizing real-time camera-image analysis. The visual control system must be usable with any camera or web camera with sufficient resolution and image quality. The individual challenges are:
  - To develop a simple model of 2D robotic arm/manipulator
  - To implement the image recognition algorithms for position analysis of defined visual element
  - To implement the communication interface with the manipulator
  - Test the portability and usability of different HW configurations

Work description:

The Poznan PUT working site was chosen for the project, which is known to the proposer to deal with similar visualisation problems and thus has requested level of experience in this subject. The real-time camera image recognition is a complicated field realized by complex algorithms with high system requirements. For such system to work properly the high-performance hardware and specific lightning and image properties must be provided. Also the efficiency of the image recognition algorithms efficiency must be ensured in order to exploit the contemporary multi-core CPU architecture. The steps in development were made during the project solution and also during the preparation stage to ensure the final visualisation system fluent and trouble-free run.

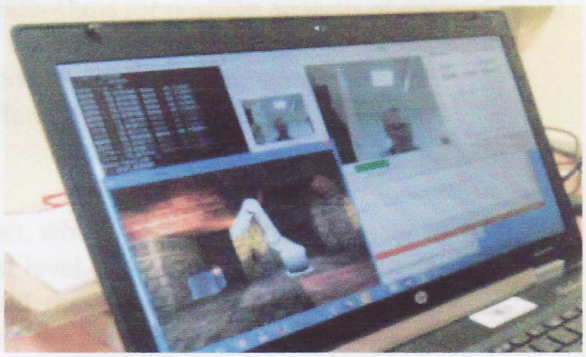
Results:

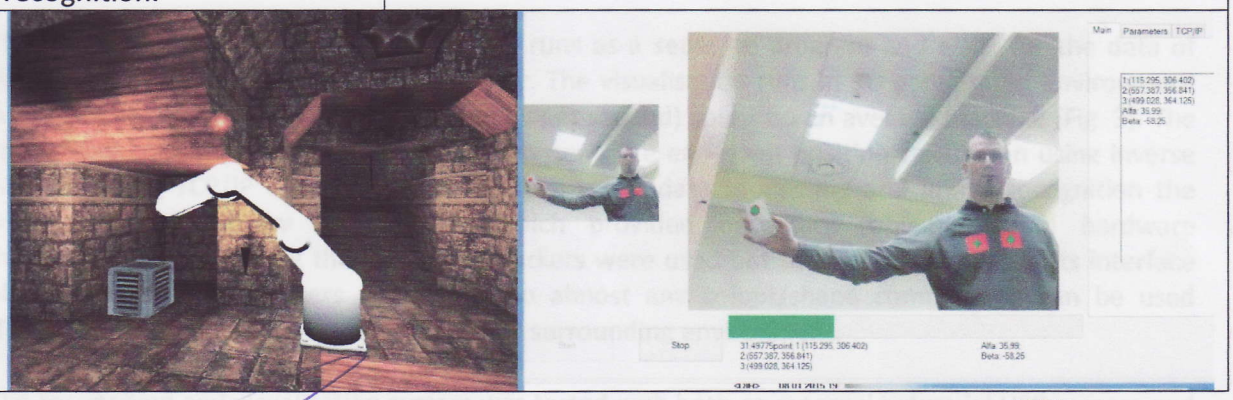
For manipulator animation the model of *Motoman MH5* robot was implemented into attractive 3D environment available under the free open source licence of 3D graphic engine *Irrlicht* [Fig. 1]. The communication protocol *TCP/IP* was used for development of *client-server* program topology where both program parts can run on one computer [Fig. 2] or on different machines connected by Ethernet network. Thus if only computers with low computational power are available the hardware demands are distributed.

The visualisation itself (the client program) runs as a separate program and waits for the data of manipulator position provided by the server. The visualisation runs in 3D accelerated environment with low GPU demands and high FPS (frames per second) count on an average machine [Fig. 3]. The server side contains the image recognition system, the end-point position calculation using inverse kinematic and TCP/IP communication. For the visual data processing and image recognition the *Machine Vision Library* was utilized which provided necessary robustness and hardware independence. For testing the red paper markers were used but the vision system and its interface allows real time parameters adjustment so almost any colour/shape combination can be used [Fig. 4]. The only condition is high contrast to surrounding environment.

The recognition and visualisation system was tested with both an external industrial USB camera and basic laptop web camera and it was proved that with selected solution reliable and fast results can be obtained with an ordinary hardware equipment. Developed system utilizes image recognition algorithms, computation of inverse kinematic problem, TCP/IP communication protocol and virtual environment and manipulator model animation.

Table of figures

Fig. 1: 3D environment imported from Irrlicht library.	
Fig. 2: Both Server and client side can run together on a single computer.	
Fig. 3: Graphic engine allows the visualisation to run smooth even on weak computers (depicted over 400 PFS on ordinary notebook). Fig. 4 (below): Real-time control of virtual manipulator using red markers for position recognition.	



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