Binocular System for the Calibration of Robotic Devices

Project Proposal

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The *Robotic Mechanical Systems Laboratory*, in collaboration with the *Artificial Perception Laboratory*, both of McGill University's *Centre for Intelligent Machines*, are developing a system for the geometric calibration of robotic devices, based on a binocular camera, *Bumblebee*, manufactured by *Point Grey Research Inc.*, of Richmond, BC.

The Bumblebee functions on the principle of parallax, according to which depth is perceived by the brain because of the difference of the image of the same object and its background, as seen by each eye. This difference arises from the separation between the two eyes of living organisms. A Bumblebee binocular system is installed at the *Robotic Mechanical Systems Laboratory*, as shown in Fig. 1.

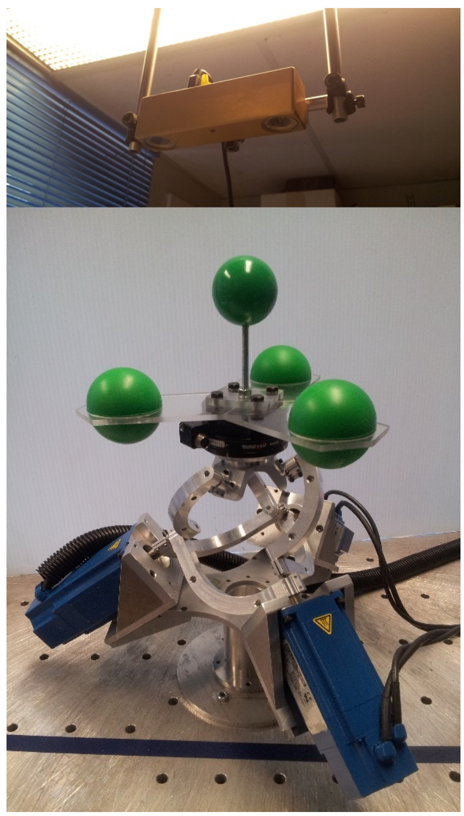

Figure 1: The Bumblebee binocular camera and the Agile Wrist

In the figure, the Bumblebee is installed above the *Agile Wrist* (AW), a haptic joystick. The AW is a three-degree-of-freedom parallel-kinematics machine (PKM), namely, a *spherical linkage* consisting of a base platform (BP) and a moving platform (MP), both connected by means of three limbs, each consisting of a proximal and a distal link, the two coupled by means of a passive revolute (R) joint. Moreover, the proximal link is coupled to the BP by means of a R joint actuated by a motor, while the distal link is coupled to the MP by means of a passive R joint. Since the linkage is of the spherical type, the axes of all nine R joints must intersect at one common point, O, the centre of the linkage.

In practice, machining and assembly errors are unavoidable. Because of these errors, a spherical linkage, as described above, is impossible to assemble—the linkage thus described is, in fact, a hyperstatic structure. In order to allow for assemblability, all six passive R joints were replaced by cylindrical (C) joints, implemented by means of needle bearings.

The purpose of the calibration is to identify the main items of the geometric errors. These come mainly from the machining of the six links, whose R joints must have axes (*i*) at 90° and (*ii*) intersecting. The aim of the calibration is thus to determine the actual values of the angles between the axes of the two R joints carried by the same link. The offsets between joint axes being equally of interest, is in the R&D plans, once the current system is functional, as described below, but their identification falls beyond the scope of this project.

Preliminary tests were conducted on a first version of the AW linkage, which was found to contain inadmissible errors, the source having been identified as a BP with mountings of the three motors that were prone to assembly errors. The BP was redesigned for *robustness* against such errors.

For purposes of MECH498, the project is divided into two stages. In the first stage, the data-acquisition software of the Bumblebee is to be revised, so as to allow it to pick up, at every posture of the linkage, the three Cartesian coordinates of the centres of the four green balls shown in Fig. 1. The current system, as provided by *Point Grey*, is capable of picking up the coordinates of one single point at a time, which makes the calibration procedure extremely lengthy. The second stage, the subject of a follow-up project for MECH 499, is the calibration of the AW with the refurbished Bumblebee code and the redesigned BP.

The MECH498 project thus relies on software engineering work. This is eased by the C++ language on which the code is written, given that this is an *object-oriented language*. The *Artificial Perception Laboratory* will provide, under Prof. Ferrie's direction, the technical support needed to become acquainted with the C++ language and the data-acquisition and data-processing.