Image Processing and Computer Vision Research Laboratory (IPCV-LAB)

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IPCV-LAB robot VISION

About

In the IPCV-LAB we carry out basic research for the development of new computer vision-based technologies, which from the processing of multidimensional signals, such as video signals and/or depth signals, are able to automatically estimate the shape, color, position, orientation and motion of real objects, for applications such as autonomous robotics for space exploration, teleoperation of humanoid space robots, video compression, on-line monitoring of biological processes, and on-line inspection for the semiconductor and food industries.

Short biography

Geovanni Martínez received his Doktor-Ingenieur degree (Dr.-Ing.) from the Institut fuer Theoretische Nachrichtentechnik und Informationsverarbeitung (TNT) of the University of Hannover, Germany, in 1998. His doctoral thesis was on computer vision-based human shape, motion and color estimation for very low bit rate video compression. His thesis supervisor was Prof. Dr.-Ing. H.-G. Musmann. From August 2000 to June 2002, he conducted postdoctoral research work on computer vision-based human motion estimation for teleoperation of a humanoid space robot called ROBONAUT at the University of Houston and NASA Johnson Space Center. In 1997 he joined the faculty of the University of Costa Rica, where he is now a full professor. He is the founder and coordinator of the Image Processing and Computer Vision Research Laboratory (IPCV-LAB). He is currently working on a computer vision-based algorithm, known as monocular NIR ToF odometry, capable of determining the position and orientation of an exploration robot from the processing of two signals, a monocular near-infrared (NIR) video signal and a time-of-flight (ToF) depth signal. He also has research experience in computer vision-based monitoring of biological processes using in-situ microscopy and in computer vision-based inspection for the semiconductor and food industries. Early in his academic career, he had the opportunity to work on the design, implementation and testing of flexible, low cost, and expandable digital private automatic branch exchange (PABX) systems. He has numerous publications in international refereed and indexed conferences and journals. In 2002 the Costa Rican government awarded him the Clodomiro Picado Twight National Technology Award for his outstanding trajectory in the area of technological research. In 2010 he received the Researcher Award from the University of Costa Rica for his contributions to the technological development of the country.

Main research project

Planetary exploration robots must be able to move autonomously following paths previously sent from Earth or planned by the robots themselves at exploration sites. Thus, they must carry technology capable of determining their 3D pose (position and orientation) at any time, as that knowledge can be used to detect whether they are deviating from planned paths. If deviations are detected, the robots must initiate the necessary control actions to modify their courses and return to and remain on their intended paths, otherwise, they might get into places from which they would not be able to extricate themselves without damaging their structures, jeopardizing a full day of exploration or even an entire mission. To contribute to the solution of this problem, we are currently investigating an algorithm capable of determining the 3D pose of an exploration robot from the processing of two signals, a near-infrared (NIR) video signal and a time-of-flight (ToF) depth signal, both provided by an NIR ToF camera rigidly attached on the side of a robot facing the terrain. We want to demonstrate that it is possible to obtain the pose of the robot by processing a monocular video signal and that, if the depth signal is also considered in the processing, it is also possible to determine it very accurately in irregular terrain. Moreover, since the camera works in the near infrared region of the electromagnetic spectrum, the algorithm is also able to work in the dark and is not affected by local illumination changes due to moving shadows. On the other hand, the algorithm does not attempt to estimate the robot pose in a single stage, as is traditionally done with nonlinear estimation techniques that usually require very good initial conditions and the establishment of feature point correspondences, but in two stages, first estimating the frame-to-frame robot motion, and then integrating the estimated motion over time using composition rules. To estimate the frame-to-frame motion of the robot, the photometric error at observation points is minimized, which is expressed in linear form allowing the minimization to be performed using an iterative and compact maximum likelihood estimator, which does not require special initial conditions or establishing any correspondence between observation points. The algorithm was implemented in the programing language C under Ubuntu and ROS operating systems. Hundreds of experiments have been conducted over rough terrain, obtaining excellent absolute position and orientation errors of less than 1 % of the distance and angle traveled, respectively, which are mainly due to the algorithm's more accurate knowledge of the depth provided by the NIR ToF camera. The algorithm runs in real time and can process up to 50 fps at VGA resolution on a conventional laptop computer. Currently we are extending the algorithm to simultaneously map the location the robot has passed through, in order to transform it into a monocular NIR ToF simultaneous localization and mapping algorithm, which we have named direct monocular NIR ToF SLAM.

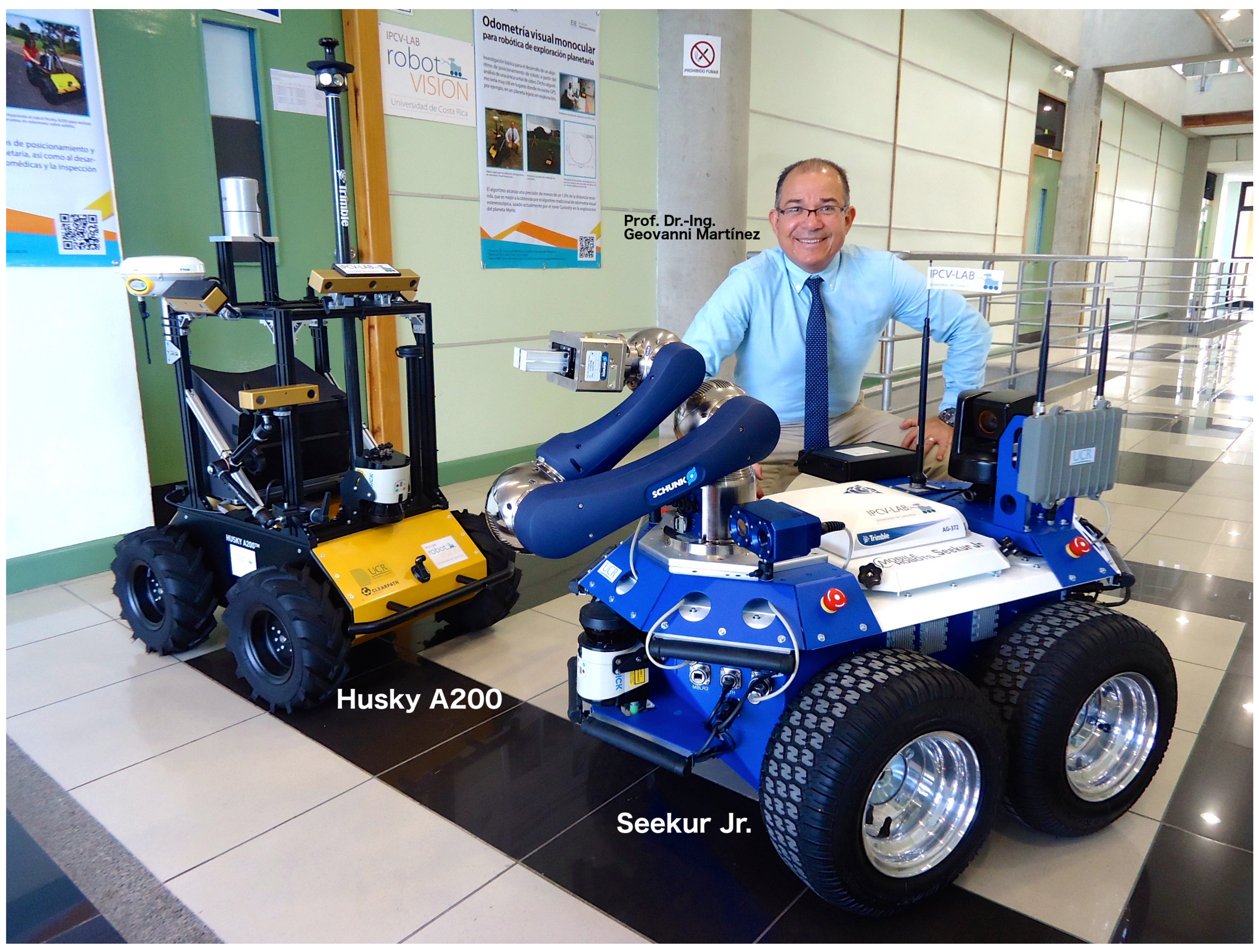

Figura 1: Robots used to test the new NIR ToF odometry and SLAM technologies developed at the IPCV-LAB for autonomous navigation systems.

Awards

- Clodomiro Picado Twight National Technology Award 2002
- University of Costa Rica Researcher Award in Engineering 2010