Calliope: Mobile Manipulation from Commodity Components

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Abstract

Calliope is an open source mobile manipulation platform built from an iRobot Create base, an ASUS netbook, a pan/tilt mount with a webcam and IR sensor module, and a 5 degree of freedom arm with gripper. It is intended for undergraduate robotics education and graduate level research.

Introduction

The iRobot Create is a popular mobile platform for educational use (Touretzky 2010) that becomes much more capable with the addition of an on-board computer such as a laptop or netbook. Many variations on this theme have been explored over the last few years. Here we present a step beyond the "Create plus computer" model by adding a camera and IR rangefinder on a pan/tilt mount and a 5 degree of freedom arm with gripper .

A camera that moves independently of the base allows the robot to track landmarks as it navigates, or to perform visual searches without moving its body. Adding an arm allows students to experiment with manipulation tasks. Together these features provide a powerful yet relatively inexpensive platform for mobile manipulation that is well-suited to the undergraduate education market.

Hardware

The hardware components of Calliope can be divided into two categories: consumer items that are mass produced in China and hence very inexpensive, and specialized technical items that are less complex yet considerably more expensive.

The commodity components are:

- iRobot Create base: $220 retail, including rechargeable battery, charger, and USB cable. The Create is the educational (vacuumless) version of the Roomba robot vaccum cleaner. iRobot has sold over 5 million Roombas.
- ASUS Eee 1001 PC netbook: $250 at Toys'R'Us. This 10.1 inch netbook features an Intel N450 Atom processor at 1.667 GHz, 1 GB of RAM, and a 160 GB hard drive.
- Sony PlayStation Eye webcam: $35 from Amazon.com. We previously used a Logitech Communicate Pro 9000 webcam, but are experimenting with the newer, less expensive Sony unit because its higher frame rate should reduce the effects of motion blur.

The specialized components include:

- Four Robotis Dynamixel AX-12 servos: $45 each retail. These relatively low torque servos are used in the pan/tilt and gripper.
- A collection of higher torque Robotis Dynamixel RX-series servos for the arm. These include the RX-24 ($140 retail) and RX-28 ($210 retail). The exact arm configuration is still being refined.
- Two USB2Dynamixel interface modules, one for the AX servos and one for the RX servos: $50 each, retail.
- A Robotis AX-S1 sensor module with three-direction IR rangefinder: $50 retail.
- A 5000 mAH NiMH battery and charger to power the arm and pan/tilt: $70 retail.
- A custom fabricated baseplate for mounting the laptop and arm on the Create, and a "neck" for mounting the pan/tilt.
- Miscellaneous components: servo cables, SMPS2Dynamixel adapter board, power switch, mounting plates for the webcam and finger servos, gripper fingers.

The total parts cost is $1600-1700, plus shipping charges. Note that the two most complex components, the Create base and the netbook, account for only one third of this cost. While our design is open source, allowing anyone to build their own Calliope, fully-assembled versions will be available from RoPro Design for those who prefer the convenience of a ready-to-run solution. The projected retail cost of a fully assembled robot is under $2500.

Software

We install Ubuntu Netbook Edition on the ASUS. This is a popular Linux distribution optimized for machines with small displays: 1025x600 in this case.

Calliope was developed with the Tekkotsu robotics software framework in mind. Tekkotsu is free, open source software that emphasizes a high level approach to robot programming; see Tekkotsu.org for more information.

Another group is developing Player/Stage support for Calliope, which should be available soon. Player/Stage (Rusu et al. 2007) is also an open source framework.

Results

An initial prototype was exhibited at AAAI-10 in Atlanta. We demonstrated landmark tracking with the pan/tilt, and simple manipulation using canned motion sequences for the arm and gripper. Future work will include arm path planning and grasp planning, and use of the pan/tilt to enhance the robots navigation abilities.

We are still in the early days of educational robotics. As consumer products are developed that utilize good quality servos, their mass production should lead to a dramatic decline in component costs for educational robots.

References

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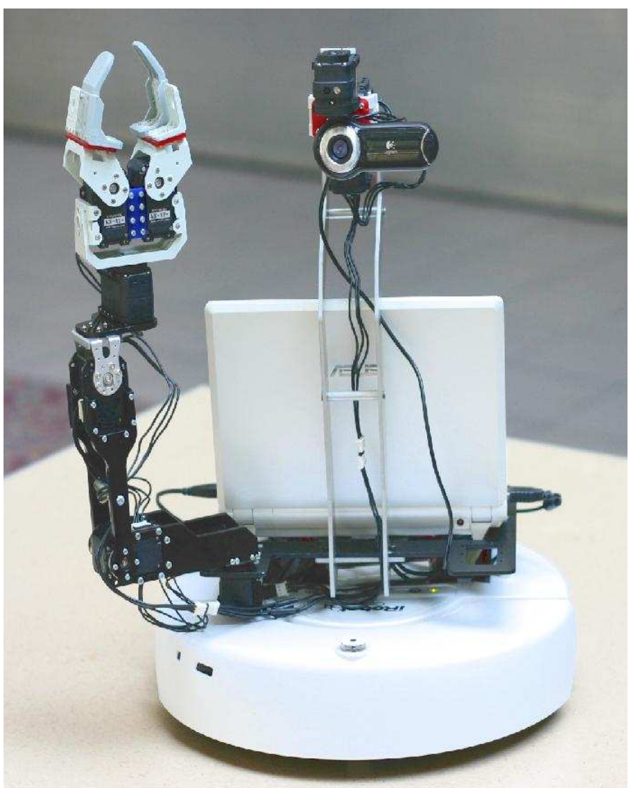

Figure 1: Calliope prototype demonstrated at the AAAI-10 Robotics Exhibition.

Acknowledgments

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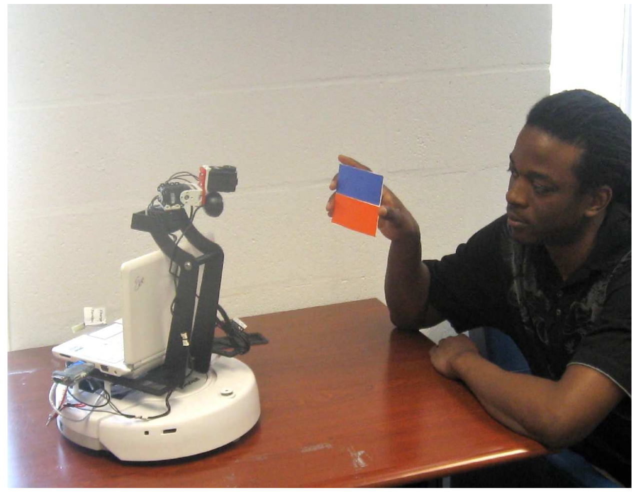

Figure 2: Student researcher Owen Watson holding a marker which Calliope is tracking with its pan/tilt.

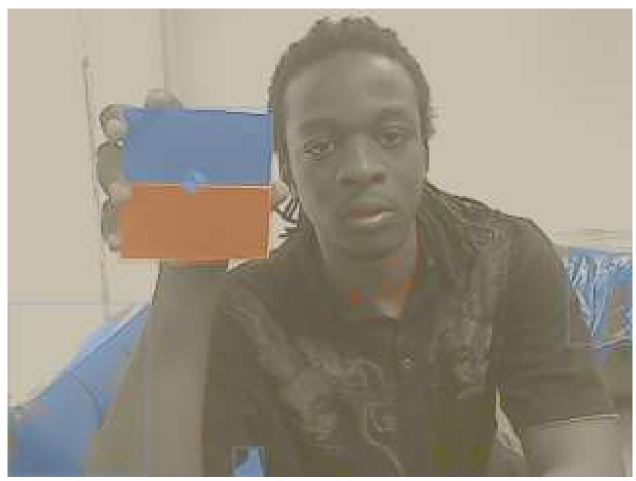

Figure 3: Tekkotsu SketchGUI display of the color segmented camera image showing the robot's view of the marker, with a target symbol indicating the marker center.