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Embedded Single Board Computers for Robotics

Introduction

Semi-autonomous robots require onboard computers powerful enough to be able to process commands for locomotion control as well as accommodate other potential input/output functions, such as teleoperations or position sensing. These computers also need a compact size and low power consumption in order to decrease physical and electrical load on the robot, constraining the choices to embedded single board computers (SBCs) instead of more modular slot based SBCs. This paper is a review of single board computing viable for robotic control systems.

Commercial Applications of Embedded Single Board Computers

Customized embedded SBCs are in a variety of modern technologies that require control interfaces coupled with low cost and power consumption. These products include medical instruments, industrial automation controllers [1], ATMs, cash registers, and interactive kiosks [2]; however, the custom boards are typically specialized for their particular machines and lack open-source software support. Researchers and hobbyist programmers focused on prototyping projects more often utilize commercially available open-source SBCs [3] such as the BeagleBone Black, costing $55, or the Raspberry Pi 3, costing $35. Primarily running on Linux distributions like Ubuntu, open-source SBCs have numerous applications, ranging from wearable computing to video game emulators, household monitoring systems to compact media players, and mobile app communication to robotics [4][5].

Underlying Technology of Embedded Single Board Computers

Embedded SBCs function like almost exactly like most commercially available computers, with the major exception that all components on the board are integrated with the system and are not modular. Primary specifications of SBCs include the operating system, CPU, RAM, storage, networking, GPIO pins, and power consumption [6].

OS

Almost all SBCs run on a Linux distribution, with some extending functionality with other distributions or a Windows OS [6]. The BeagleBone Black is notably also integrated with Robot Operative System (ROS), an operating system designed specifically for robotics development [7].

CPU and RAM

The average strength of embedded SBC processors ranges from 1 GHz to 1.6 GHz on Intel or ARM processors, while the board memory is typically 512 MB or 1 GB, but can go up to 32 GB [8]. For example, the BeagleBone Black contains a 1.2 GHz processor with 512 MB onboard RAM [9], while the Raspberry Pi 3 has a 1.2 GHz processor with 1 GB of RAM [10].

Storage, Networking, and GPIO

Storage memory, networking capabilities, and the number of GPIO pins can be affected by the particular model of SBC chose. Onboard flash storage for SBCs is commonly 4 GB if available, but there may be SD card slots if additional storage space is required [11]. The SBC is able to network via its Ethernet port to power itself or connect to the internet if the board does not have a Wi-Fi module [6]. Finally, the total number of GPIO pins for receiving inputs and outputs varies significantly between boards and can range from less than 10 to over 100 [6].

Power

Power consumption should be maintained at a minimum to decrease the need for cooling, but depending on the application of the SBC, additional cooling of the system may be required. The power consumption of an SBC is usually lower than 10 W, with increases of around 2 W if the CPU is loaded [6].

Building Blocks for Implementation

The only equipment needed to interface with the SBC is an Ethernet or USB cable to link the board and allow it to be programmed, an HDMI cable with a monitor to view coding progress, and an appropriate power source for the SBC. SBCs are commonly preinstalled with an OS already, which satisfies the software requirements.

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