Quadruped Robot

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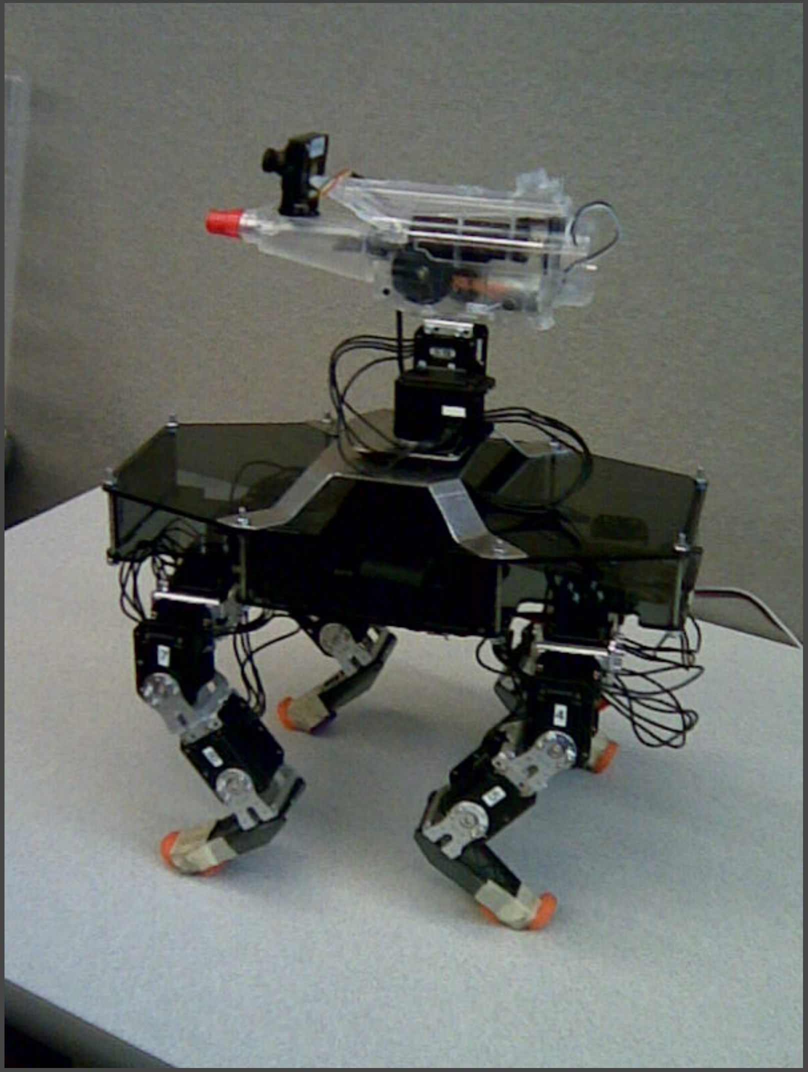
Requirements Statement

Produce a quadruped robot capable of navigating an obstacle course by both traversing and avoiding obstacles. The robot's gait must be dynamically generated using an onboard BeagleBoard embedded Linux system, with the goal of participating in Texas Instruments' Analog Design Competition.

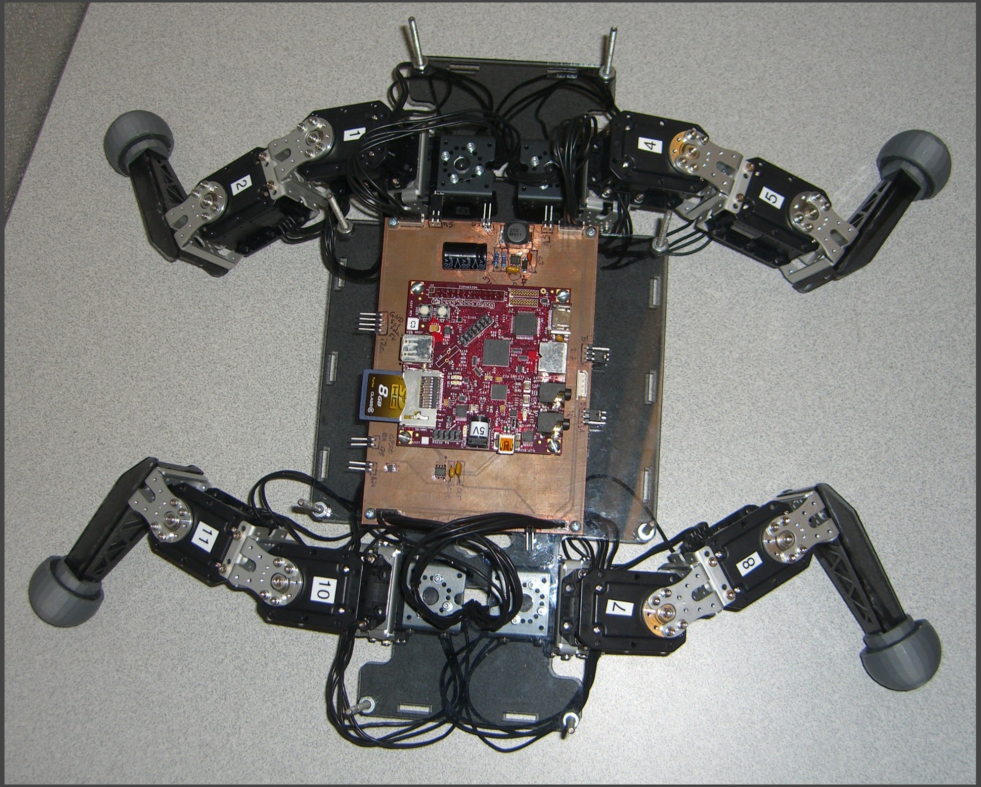
Starting Point

- Quadruped chassis developed last year in collaboration with Seoul National University of Technology
- Previous electronics were large and heavy, resulting in slow walking speed
- Time pressure limited sophistication of software



Robot Overview

- The robot is comprised of three main components
- Four legs, each made of three servo motors
- The BeagleBoard, the brain of the robot
- An interface board to connect the BeagleBoard to sensors, servos, and peripherals.



Why the BeagleBoard

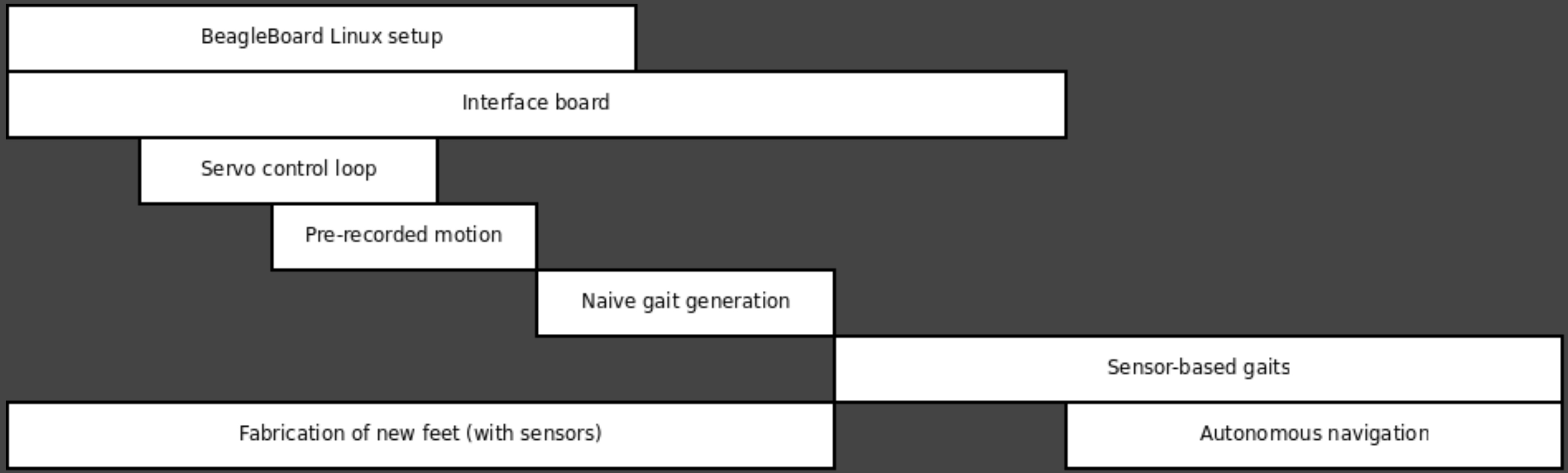
- Previous design utilized two processors, interfaced over a CAN bus
  - dsPIC33 for motion control
  - TMS320 (C6000) based DSP board for image processing
- This was unnecessarily complex, very expensive, and physically large
- Our solution is to utilize the Texas Instruments BeagleBoard

Why the BeagleBoard

- Attractive for a number of reasons
    - Physically small: 3" x 3.1"
    - OMAP3 SoC
        - 600MHz ARM-Cortex general purpose core
        - 430MHz TMS320 DSP core
    - Low power consumption (~2W)
    - Low cost ($150)
    - Fully supported under Linux
    - Large expansion header providing access to extra UARTs, SPI, I2C, and GPIO

Development Process

- Iterative development process for both electronics and software
- Tasks parallelized based on team member expertise



BeagleBoard Linux setup

Interface board

Servo control loop

Pre-recorded motion

Naive gait generation

Sensor-based gaits

Fabrication of new feet (with sensors)

Autonomous navigation

Risk Management

- Time constraints
  - Risk: delay in manufacturing
  - Risk: delay in parts shipment
  - Coping:
    - Plenty of schedule slack
    - Back-up interface to hardware
- Image processing: DSP on the Beagle
  - Risk: know little about using the DSP chip
  - Coping:
    - Don't depend on the DSP; processing can be done on the ARM core

Current Status

- Hardware: Operational
  - Working to get new feet manufactured
- Electronics: Rev. A interface board complete
  - Will begin Rev. B in a week once testing has been completed
  - Final rev. planned for 3rd week winter quarter
- Software: Porting recorded gait
  - Will begin work on dynamic gait generation once static walking is complete
  - To start with crawl, then proceed to a trot

Software

- Written in C using Glib
- Currently have motor communication code largely complete; working on control code
- Will be broken into threads for major subsystems
  - Motor control
  - Gait generation
  - Sensor data processing
  - Navigation
- Next: Walking based on predefined pattern, then gait generation under manual control

Interface Board, Rev. A

- PCB to interface BeagleBoard with the rest of the robot
- Components:
    - Switching regulator to reduce 14.8V input to 5V for the BeagleBoard
    - Level-shifters to allow interfacing with 3.3V/5V peripherals (I2C, GPIO)
    - RS485 transceivers to communicate with servos

Interface Board: Rev. B

- The next iteration of the interface board will have all the functionality of the current board, with some additional features
    - On-board charging and protection circuit for LiPo battery pack
    - Triple-axis accelerometer/gyroscope
    - Connectors for foot contact sensors
    - Support for USB peripherals
    - Possibly an on-board USB hub and USB to ethernet adapter

Any Questions?