



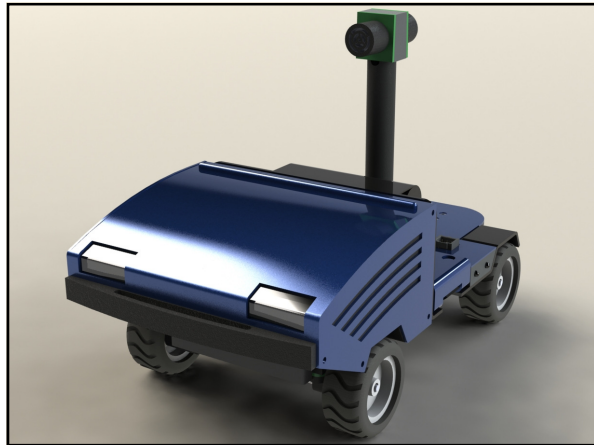


COLONY SCOUT UPDATE

Daniel Shope, Kevin Woo, Bradford Neuman


2's Company

- Designed to complement Colony III
 - Evolution on existing technologies
- What do you want?
 - “Better” sensors
 - Robust mechanical platform
 - Environment Manipulation
 - Expandable Hardware
 - Real Multi-tasking
 - More Computational horsepower ☺



System Overview

- 4WD all-terrain platform
 - High speed, high torque motors
 - Integrated quadrature encoders (~3mm linear accuracy)
- Enhanced Sensor Package
 - Sonar rangefinders
 - Digital cliff sensors
 - Side proximity sensors
 - 3 axis accelerometer
 - Yaw rate gyroscope
- Integrated charging contacts & homing




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SENSOR SUITE

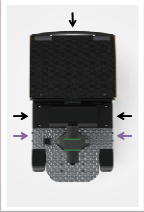
Sonar Rangefinders

- Maxbotix Sonar Rangefinders
 - 0-254 inches (no dead zone)
 - Serial, Analog, or PWM interface
 - Positioned by stepper motor
 - 49ms per measure and transmit cycle
- Sensors tied in to vehicle speed
 - High speed
 - 1-6 point scanning for high sampling rate
 - Obstacle avoidance threshold extended
 - Low Speed
 - 6-48 point scanning for maximum point density
 - 150ms to 1.12 second acquisition
 - Obstacle avoidance threshold minimized



Proximity Sensors

- 3 Zone Cliff Sensors
 - Digital Interrupts
 - Create perimeter around base
- Left/Right Proximity Sensors
 - Basic reflectivity sensors for wall-following
 - Complement sonar rangefinders

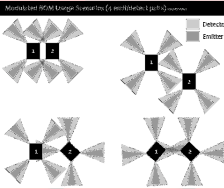


Inertial Measurement Unit

- Gyroscope
 - Single axis (yaw)
 - 300deg/sec (50rpm)
- Accelerometer
 - X,Y,Z axis
 - +/- 16g (13bit) resolution
 - Tap & Double Tap detection
 - Free-fall detection
 - Built-in self test

BOM

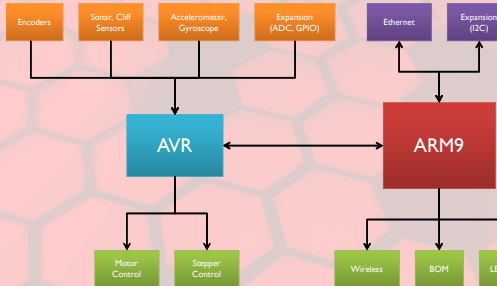
- Bearing & Communications
 - 4 emitter/detector pairs
 - >6 ft range (might extend to over 10 ft)
 - Transmits robot ID and sensor position
 - Extrapolate orientation between robots
 - Hardware has integrated amp, filter, demodulator



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PROCESSOR/HARDWARE

Architecture





```

    graph TD
        AVR[AVR] <--> ARM9[ARM9]
        AVR --- Encoders[Encoders]
        AVR --- Sensors[Sonar, Cliff Sensors]
        AVR --- Acc[Accelerometer, Gyroscope]
        AVR --- Exp1[Expansion ADC, GPIO]
        AVR --- Motor[Motor Control]
        AVR --- Stepper[Stepper Control]
        ARM9 --- Eth[Ethernet]
        ARM9 --- Exp2[Expansion I2C]
        ARM9 --- Wireless[Wireless]
        ARM9 --- BOM[BOM]
        ARM9 --- LED[LED Orbs]
    
```

ARM9 (“Think”)

- NXP LPC3240
 - ARM9 Core
 - 32bit, FPU, MMU
 - 208MHz Clock Speed
 - 7 UARTs, 2 PWM
 - USB 2.0, SPI, I2C, IrDA, 10/100 Eth
 - 18 external interrupts
- Well suited to do the heavy lifting



ARM9

AVR (“Act”)

- ATmega 128A
 - 16MHz Clock Speed
 - Same processor as Colony III
 - Can make use of existing library
 - Current consumption ~halved from 128L
- High #of I/O make it ideal for a “relay” node
 - 10bit ADC used for IMU
 - PWM outputs used to drive motors
 - Dedicated timer for each of the (4) outputs

AVR






System Details

- Processors
 - 208MHz ARM9
 - 16MHz ATmega 128A Co-Processor
- Memory
 - 1GB NAND Flash
 - Expandable by microSD cards
- RAM
 - 256KB SRAM (integrated)
 - 512MB SDRAM



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OPERATING SYSTEM



Linux (or similar) RTOS

- Real Time kernel
 - Provides data structures and system functions that guarantee that tasks complete within a deadline
 - Multi-process architecture
 - User-space behavior code
 - Program bugs don't kill the robot
 - Behavior code can be killed and re-started



POSIX compliant OS

- Allows us to use standard UNIX tools
 - ssh
 - bash
 - Develop and compile on robot
- IPv6 networking
- Program behaviors in any language
- Logging
- Emulate with Q-Emu

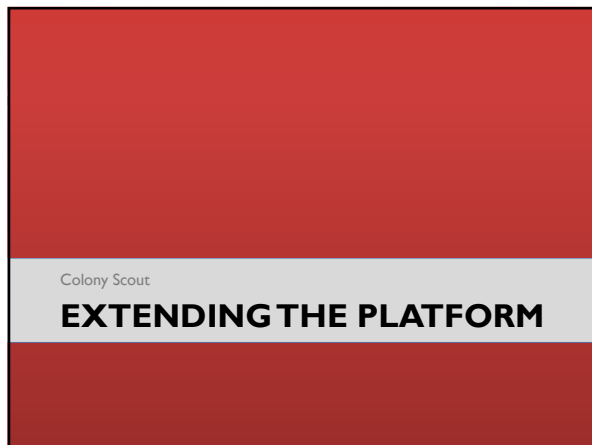


Software Architecture

- Priority Arbitration
 - Process kill or EStop
 - Remote control override
 - Cliff avoidance
- Dedicated background tasks to
 - Motor/ Odometry control loops
 - Obstacle avoidance
 - Wireless

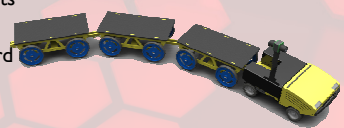
Wireless Communication


- IPv6 Stack
 - Wireless speed up to 2Mbps (vs. 115kbps)
 - Range: 1 mile line-of-sight
 - Equivalent or better than Xbee Pro
- Uses premade TCP/UDP Library
 - Built in Layer 3 Mesh Network
 - Using a routing bridge, can connect over the internet
- Cheaper and faster than Xbee 2.0

Extensibility Interface

- Power and data
 - 5V, 3.3V
 - (2) Analog Inputs
 - (2) Digital IO
 - Smarts Onboard
 - I2C to ARM9
- Attachment
 - Rear of robot open for accessory installation
 - (6) #4-40 threaded hardpoints
 - 1/4" bushing for turntable support







Automated Retrieval System

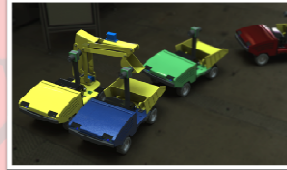
- Autonomous distribution center
 - Robots handle package moving
 - Localization
 - Obstacle/Robot Avoidance
 - Path Planning
 - Object manipulation
 - Autonomous Recharging
 - Pull moving tasks from central server
 - FIFO, tasks assigned based on timing priority and bot proximity
- Hardware
 - Forklift Accessory
 - 6"+ vertical travel
 - Tilts back for package holding
 - Limit switches for simple positioning







Dig N' Haul

- Autonomous earth moving demonstration
 - Localization
 - Obstacle/Robot Avoidance
 - Coordinated object manipulation
- Hardware
 - Digger
 - Multi DOF arm
 - Articulated bucket
 - Hauler
 - 2 lb capacity bucket
 - Analog load cell

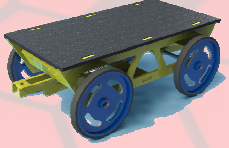


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Smart Payload Interface


- Wagon style hauling
 - Low rolling friction enables high capacity
- Units can be daisy chained
- Payload can plug into the network
 - Haul a sensor package, etc
- [Video](#)



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PLATFORM MAINTENANCE


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Autonomous Recharging

- 12V+ Rails
- 24W per robot at peak charging rate
- Integrated homing, charging contacts
- Next evolution of ARCHS
 - Expanding Colony III server architecture for managing resources
 - Same voltage requirements, at higher current

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Cubbies 2.0

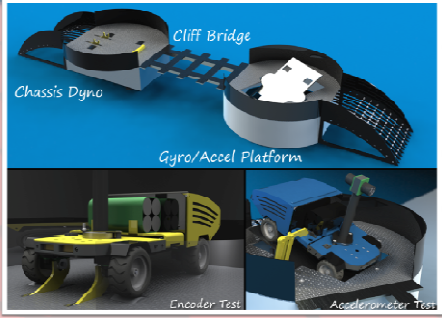
- Integrated Charging Contacts
 - Logic remains powered on
- Wired Ethernet Connection




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Diagnostics Station




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Scout Remote Control

- Assume control over one robot
 - Robot ID can be dialed in on the remote
 - No reprogramming for specific device control
 - Onboard LCD for diagnostic info display
 - Supports two way communication
 - Multiple remotes can be used simultaneously
 - No plans to support accessory control



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IN DEVELOPMENT



What can you do?

- Need to develop AVR \leftrightarrow ARM9 interface
- Incorporate IPv6 wireless library
- Diagnostics Station
 - Server code, design hardware tests
- Charging Station
 - Power distribution design, homing beacons
- Accessories
 - Have a cool idea? Make it a reality!

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QUESTIONS?