Robert S. Grimes

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Mission Statement

Lead multi-disciplinary teams in the development of exciting new technology that positively impacts customers' lives far beyond their expectations.

Technical Skills

- Experienced embedded systems architect, designer, and developer of real-time systems for iRobot, NASA, DOD, MIT Space Systems Laboratory, MIT Lincoln Laboratory, FLIR Unmanned Ground Systems, Ohio State University, Aurora Flight Sciences, Universistat Bern, and other clients. Created and managed numerous microprocessor, DSP, and communications hardware and software projects.
- Experienced VHDL developer, particularly with Xilinx FPGA devices. Experience with embedded ARM and PowerPC processors in Zync-7000 SOC and Virtex FX devices, combining traditional VHDL components, processor IP peripherals, and software to create high-performance real-time processing solutions.
- Experienced Linux developer, utilizing C/C++, XML and related technologies, Git and Subversion revision control system, Jira issue tracking and software management tools, PHP, Python, Perl, etc.
- Experienced Windows developer, utilizing Delphi, C++, VBA, COM, HTML, CSS, JavaScript
- Leadership/mentorship: Lead teams of software and hardware engineers, mentor new engineers through constructive criticism, insightful questions, shared experiences, and professional support
- Fluent in Jira, Confluence, Bitbucket, Jenkins, Slack collaboration tools
- Well-versed in agile, military, and NASA development processes, requirements analysis, verification and validation, interface control, mission assurance, and documentation.
- Processors: Intel, STM32 ARM family, Xilinx Zync-7000 SoC, PowerPC, Sparc/LEON, Atmel ATmega family, MicroChip PIC family, TI TMS320C30/40/6701, Motorola ColdFire and 683xx, Rabbit, others
- Languages: C++, C, Python, Delphi, Pascal, VHDL, JSON, XML, XML Schema, XSLT, HTML, CSS, JavaScript, SQL, Visual Basic for Applications, Assembly, Fortran, Lua, PHP, Perl, etc.
- Applications: Xilinx Vivado and ISE, Doxygen, OrCAD schematic capture, Microsoft Office, Visio, Powerpoint, Project, LabView, Matlab/Octave
- Operating Environments: Linux, Windows, FreeRTOS, Robot Operating System (ROS), AUTOSAR, RTEMS and other RTOS, COM/DCOM, Git, Subversion, Trac, CVS, SQL, mySQL, TCP/IP, Controller Area Network (CAN)

Experience

iRobot Corporation — 4/2021-Present

Consulting Embedded Engineer

Clean Base Architect: Continued lead architect and developer for iRobot's family of Clean Base products. Responsible for extending the architecture to support new Robots currently under development. Designed and implemented all communications protocols between the Dock and client Robots, over a variety of media (e.g. IrDA, BLE, custom communications over charging contacts, etc.)

Supply Chain Consultant: Involved with incorporating alternate chips to address supply chain problems, developing frameworks for more readily supporting alternate devices.

RSG Associates 1994-Present

Embedded Computer Systems Consulting

Client: IRobot Corporation *8/2011 – 4/2021*

Lead Embedded Engineer, Clean Base: Primary architect and developer for iRobot's family of Clean Base products. Spearheaded and drove a modular, reusable architecture and codebase that supports all iRobot Clean Base and regular charge docks. Elevated importance and recognition of docks as integral components to robotic systems, rather than simply an afterthought.

Lead Embedded Engineer, Special Projects: Regularly called on to lead software investigation into a variety of issues (internal and external) that impact fielded robots. Such issues have included new EU safety requirements, more stringent California (and later, DOE) energy consumption requirements, and others.

Lead Embedded Engineer, Roomba: Develop firmware for several microcontrollers for acquiring and aggregating a wide range of sensors for the next generation Roomba. In addition to interfacing to the sensors, this involves a flexible framework for later adaptation, once the ultimate sensor suite is determined. Recently, concluded porting of existing robot code to a new microcontroller. Leading adoption of improved documentation as part of team philosophy. Demonstrated initiative in developing and championing a customizable, encrypted bootloader for use in all deeply embedded microcontrollers, eliminating prior practice of copy/customize approach.

Lead Embedded Engineer, Remote Presence: Developed firmware for microcontroller that controls a video teleconferencing payload on the iRobot Ava 500 business remote presence robot. This includes vertical lift to maintain eye-level contact, camera tilt, and user interface buttons/indicators. The microcontroller interfaces to the robot's main processor, providing command, control, and telemetry interfaces to the host.

Lead Embedded Engineer, Military Robotics: Responsible for redesign and implementation of enhanced audio/video DSP subsystem. The DSP acquires video from multiple sources, then compresses and streams the data to the main processor. The DSP acquires audio data, also streaming that to the host, and plays received audio data. It is also responsible for controlling cameras, as well as several different lighting modules.

Lead Embedded Engineer, Military Robotics: Responsible for redesign and implementation of supervisory microcontroller. This microcontroller controls the power up and down sequences, monitors the battery subsystem, current usage, and overall system state, and communicates with the main, Linux-based robot processor. The code was a legacy design, not well designed nor documented, with no ownership within the client's organization. The project involved a major redesign to improve the robustness and maintainability of the code, and completely document it for future maintenance.

- Communications Redesign. The overall communications with the rest of the robot was inherently fragile and susceptible to inadvertent messages; a robust, packet-based communications protocol was developed to address these issues.
- Improved Modularization. The original design suffered from poor modularization, with excessive coupling between modules. A plethora of global variables, most of which were not even necessary, were eliminated. Over a dozen serious bugs were found and eliminated.
- Interface Library and Test Program. On the main processor side, an existing Linux-based library was thoroughly revamped to implement the new communications protocol, as well as implementing new functionality. A test program that thoroughly exercises the microcontroller and protocol was developed.
- Documentation. The developed software was thoroughly documented, both in-line using Doxygen and in an off-line detailed design document.

Lead Embedded Engineer, Advanced Development: Responsible for rapid prototyping and demonstration of new sensors, actuators, and software for proof-of-concept and risk reduction, prior to introducing new technology into existing and planned product lines.

- Smart Battery System. This effort started with demonstration of System Management Bus (SMBus) and Smart Battery System (SBS) technologies, then incorporation of drivers and middleware into client's existing product software.

- Phase-based Laser Range Measurement System. Utilizing Cypress PSoC3, developed "system on a chip" controller for a phase-based laser measurement sensor system. The controller controls a spinning assembly that distributes the pulsed laser around the sensor and captures the reflected beam. The observed phase difference correlates to the distance between the emitter and a target object.
- Video Range Detection. Developed range measurement system using infrared lasers and video sensors.
- Algorithm Port. Responsible for porting a large algorithm developed on workstations onto a small, low-cost microcontroller. Developed strategies to maintain interoperability between the two platforms. Characterized and validated its operation on the embedded platform, with respect to memory and processor usage, as well as correctness of results.

Client: Ohio State University ***4/2017 – Present***

Control Systems for Vestibular Research Motion Platforms. Developed real-time control systems for a variety of motion devices for human vestibular research by the Ohio State University Medical Center.

- Multi-Platform Real-time Control System. Developed ARM/FPGA embedded Linux computer, based on Xilinx Zync-7000 SoC, to support a wide variety of motion platforms at clients' facilities. These boards support platforms utilizing analog, digital, and network based interfaces. Developed real-time firmware on the embedded computer to control the platforms in a unified manner, independent of the hardware interfaces. Also developed FPGA embedded processor configurations in support of these systems.
- Integrated Control Environment. This Windows application provides a common environment for experiment planning, motion planning, and experiment execution. Updated to operate in new ARM/FPGA embedded Linux computer, with increased configurability to support wider range of target systems. Continued development to support new/evolving science objectives.

Client: Teledyne/FLIR Unmanned Ground Systems ***10/2018 – Present***

Payload Upgrades: Design and develop ROS software for controlling upgraded hardware for payloads utilized by several robots. The node detects the hardware present and acts accordingly to provide a seamless experience for the rest of the robot. Work with electrical engineering to develop circuit designs, prototypes, and final implementation. Debug and demonstrate proper operation of new hardware. Integrate software into two different robot targets.

Military Robots: Design and develop software for controlling a disruptor for a military robot, participating in hardware design (software requirements, schematic reviews, etc.). Developed reusable firmware for several auxiliary boards for motor and power control, leveraged common hardware design to maximize software reuse. Demonstrated method to adapt existing video processing DSP into new robot software architecture. Updated build systems for legacy software products.

Client: MIT Space Systems Lab - LLAMAS ***12/2019 – 5/2022***

Operator/Engineering Console: LLAMAS is a MIT-developed spectrograph instrument for the Magellan Telescopes at Las Campanas Observatory in Chile. Developed the Huaso operator/engineering console to provide control and monitoring access to operators and engineers, both remote and local to the instrument. The console is a Python application that communicates with the instrument, providing feedback and a control interface to the operator. It also supports scripts that may be utilized to automate complex sequences.

Client: ClearMotion Corporation ***10/2015 – 2018***

Embedded Systems: ClearMotion is developing a distributed system in support of their active suspension system. Revamped the battery management firmware to fix several bugs, updated code generation tools, incorporate generated code, and developed test plans for improving state of charge estimation. Rewrote CAN driver for the main controller, implementing or upgrading four APIs for sending and receiving messages. Create fault reporting framework, and updated board support package to leverage low-level, high-value, infrastructure across bootloaders and applications, while simplifying both clients. Created AUTOSAR software component (SWC) to capture, preserve, and report low-level faults due to erroneous software or hardware failures.

Client: Massachusetts Eye and Ear Infirmary ***2007-2018***

Control Systems for Vestibular Research Motion Platforms. Developed real-time control systems for a variety of motion devices for animal and human vestibular research by the Massachusetts Eye and Ear Infirmary's Jenks Vestibular Research Lab.

- Real-time Control System for Moog 6DOF motion platform. This system uses a self-contained real-time computer to control the six-degree of freedom Moog platform. It communicates with a host computer and the Moog device via Ethernet. Motion trajectories are downloaded from the host computer, validated, and motion commands are fed to the Moog to achieve the desired motion.
- Multi-Platform Control System. Developed FPGA and analog I/O boards for commercial embedded computer to support a wide variety of motion platforms at clients' facilities. These boards support platforms utilizing analog, digital, and network based interfaces. Developed real-time firmware on the embedded computer to control the platforms in a unified manner, independent of the hardware interfaces.
- Integrated Control Environment. This Windows application provides a common environment for experiment planning, motion planning, and experiment execution. Implemented plug-in architecture for trajectory generators (for creating specific motions), "experiment advisors" (expert systems for running experiments based on subject performance), and device interfaces.
- Data Acquisition System. This LabView-based application provides readily customizable data acquisition services for laboratory experiments.

Client: MIT Space Systems Lab - REXIS *4/2015 – 10/2015*

Rescue and Mentor: REXIS is a MIT/Harvard student-developed spectrometer instrument that will collect and image fluorescent X-rays emitted by asteroid 1999 RQ36, and is scheduled for launch by NASA in 2016. As a largely student-run project, the software for this instrument was not complete and was in danger of missing delivery deadlines. Joined the team in April to review the software implementation, suggest and implement necessary improvements, implement core image processing functions, and develop in-service patching. Also served as a mentor to the students performing the bulk of the software integration and testing. Overall, the project was a complete success, as the software was completed on-time, even in the light of last minute hardware failures and science objectives changes that forced late modifications to the software.

Client: Venture Wireless Technology *12/2013 – 9/2014*

Systems Architect and Lead System Engineer: Led team of electrical, mechanical, and software engineers in the development of a novel, hand-held, materials analyzer for a well-funded startup founded by a pioneer in the field. Responsible for system level requirements allocation, system decomposition, system architecture, processor selection, verification activities, and quality assurance.

Client: MIT Lincoln Laboratory *2004-2011*

Satellite-based Laser Communications System: Developing real-time software for optical modem.

- System is responsible for controlling all transmitter and receiver subsystems.
- Developing command and telemetry infrastructure, both for the modem and for reuse with other systems in the satellite.
- Developed XML-based system for capturing FPGA register definitions, generating VHDL code for their implementation, software source code for manipulating them, and documentation.

Multiprocessor Laser Control System: Developed multiprocessor system for control of airborne military laser system.

- System is responsible for controlling four lasers, synchronizing their firing with five-nanosecond resolution.
- Field-Programmable Gate Array (FPGA) subsystem for analyzing, in real time, laser pulse characteristics (e.g. width, magnitude, timing, etc.); this analysis uses four 200 MHz A/D converters to supply the raw data, DSP elements to do the math, and a PowerPC embedded processor for higher-level analysis.

- Master processor provides all command and data management functions, aircraft interface, and system monitoring.

Requirements and Verification Management: Developed and managed software requirements and system test program for client's defense satellite program.

- Developed and maintained database of software requirements.
- Developed process for verification test development to ensure all requirements have been adequately verified, and provide status feedback to project and management.
- Developed fully automated system for running formal verification of software and hardware requirements. The automation allowed easy execution of well-controlled tests. This facility proved highly valuable, not only for its original verification purpose, but also for troubleshooting during integration with other systems.

Interface Management System: Developed database and code generation system to manage the complexity of an interface between satellite-borne instrument and the satellite bus.

- Utilized XML and XML Schema technologies to capture each of approximately sixty commands and several hundred data items (i.e. sensors, software status, etc.).
- Developed XSLT stylesheets to generate all code necessary to validate commands, unpack their arguments, and invoke the associated handler. Similarly, other stylesheets generate the analogous packing functions for each data item.
- The system also generated output to ill defined, unstable, externally provided specifications; this allowed client to readily respond to change requests from their customer in a few hours, rather than days or weeks, as the specifications evolved.

Other Clients

Networked Central Controller: Responsible for system architecture, controller electronics, backplane development, sensor input, actuator output, and internal messaging for a networked central controller for a recycling material sorting system.

- System consists of one or more Subracks that communicate, via Ethernet, with a client-developed system user interface computer.
- Subracks consist of a central processor, an I/O board, a backplane, and up to twelve instrument processors.
- Central processor includes an FPGA to low-latency communications between the twelve instrument processors, the central controller, and external sensor and actuators.

uClinux-based NIR Analyzer Embedded Processor: Developed electronics architecture, hardware requirements, and software platform for small, portable NIR material analyzer.

- Specified embedded microcontroller board, and provided technical oversight of its design.
- Developed FPGA design for controlling high-speed electronics, acquiring and processing analog spectrometer data, and providing the interface with the embedded processor.
- Ported Das U-boot boot loader to target board.
- Ported uClinux to the target board, along with custom drivers, and fixing bugs or limitations in existing drivers.
- Developed libraries and application software.

Control FPGA for LCROSS Flight NIR Analyzer: Developed FPGA configuration for flight NIR material analyzer that was flown on the NASA Lunar Crater Observation and Sensing Satellite (LCROSS) spacecraft. This instrument is credited with the discovery of water on the Moon (re: "NIR Spectrometers on the Moon", Day, David, NIR News Vol 21, Issue 1, January 2010).

- Developed FPGA design for controlling high-speed electronics, acquiring and processing analog spectrometer data, and providing the interface with the LCROSS processor.

Pedestrian Detection and Warning System: Developed real-time control and user interface software for a system designed to protect pedestrians from large (e.g. jumbo dump trucks, earth movers, etc.) mining machinery. Client is a startup dedicated to the application of technology to increase worker safety.

- Utilized Xilinx Virtex-4 FPGA design to measure the transmission times of RF signals to determine relative distance.
- Created user interface utilizing a touch screen terminal to warn machinery operators of nearby pedestrians.

Fume Hood Monitor: Developed firmware for a fume hood airflow monitor to protect worker safety and warn against possible contamination.

- Embedded system monitors airflow across the fume hood opening, and generates appropriate alarms when flow exceeds configurable limits.
- Created user interface utilizing a touch screen, graphics display, warning horn, LEDs, and several keys to configure the monitor to deliver the desired functionality (e.g. alarm levels, I/O configuration, etc.).

Publications

- *Grimes, Robert S.*, "Designing with Core-based High-density FPGAs", Embedded Systems Design, July/August 2011, pg. 27-32
  URL: http://www.eetimes.com/design/embedded/4218313/Designing-with-core-based-high-density-FPGAs

Education

Massachusetts Institute of Technology

Bachelor of Science, Electrical Engineering/Computer Science

- Designed multiprocessor device control and data acquisition system for thesis.