# Evaluation of Microcontroller Wireless Technology to Enable a Smart Connected Intensive Care Units (ICU)

**Rodriguez-Paras, P.E.[1], Sasangohar, F.[1,2,3]**
sasangohar@tamu.edu; patricio.rodriguez@tamu.edu;

[1] Department of Industrial and Systems Engineering, Texas A&M University [2] Center for Remote Health Technologies and Systems, Texas A&M University
[3] Department of Environmental and Occupational Health, Texas A&M University

APPLIED COGNITIVE ERGONOMICS LAB

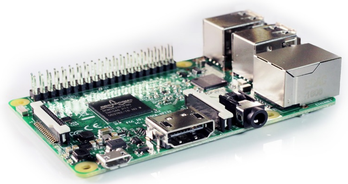
## 1. Background

**Intensive Care Unit (ICU) is a complex environment.**

- The users usually experience high cognitive workload and stress.
- Interoperability between equipment and the complexity of tasks lead to performance degeneration.

**Patients can suffer from the latent errors of poor ICU system design.**

- Mitigation of interoperability issues can lead to a better quality of the working environment, and patient treatment.
- Microcontroller and Single Board Computers (SBC)s are readily available to design cost-effective tools that can target specific needs.



Raspberry Pi SBC

**What are microcontrollers and Single Board Computers (SBC)?**

- Microcontrollers and SBCs are small but powerful computers that that are capable of controlling multiple outputs.
- Can aid with interoperability between tools

*Recent emergence of wearable devices (e.g., communication tools, smartphones, smartwatches) and wireless electronic equipment make microcontrollers and SBCs a good candidate to improve interconnectivity and interoperability among different subsystems in an ICU*

**Critical Need: to investigate the efficacy of microcontrollers and SBCs to improve interoperability in ICUs**

## 2. Research Aims

**Aim 1:** *Investigate the efficacy of microcontrollers to improve interoperability among devices in the ICU*
**Aim 2**: *Compare microcontroller capabilities to improve a wireless Task Severity Awareness Tool (TAT)*

## 3. Case Study: Development of a Task Severity Awareness Tool (TAT)

### 3.1 TAT Background

- Developed to enable nurses to inform others when a high-severity task such as medication administration is being conducted
- Tool was implemented in a cardiovascular intensive care unit (CVICU) of a Canadian teaching hospital.
- This tool consists of three actuators (two buttons and one pedal) located at the bedside, and a scrolling LED display outside the CVICU room connected to a microcontroller (Arduino Uno).
- When any of the actuators are pressed, the microcontroller detects the input, and as an output the scrolling LED display lights up with a "do not disturb" message.

### 3.2 TAT Improvement

- While the tool showed promise in mitigating unnecessary interruptions during high-severity tasks, usage required an extra step (pushing a button).
- Automated actuation of the display and wireless connection between wearable tools may mitigate these limitations.


### 3.3 Methodology for Choosing a Microcontroller or SBC and Tool design

- Several ICU-specific criteria were identified using a review of literature and subject matter expert interview
- The two dominant microcontrollers (Arduino and Rasberry Pi) were compared against these criteria using a decision matrix
- Compared to Arduino Uno, Raspberry Pi 3 was deemed superior in terms of memory space, processing power, input/output, and connectivity. While Arduino Uno is a more economical option, the capabilities are much more limited.

| Criteria | Arduino Uno | Raspberry Pi 3 |
|---|---|---|
| Analog Input | 6 | Not included, but can be added |
| Digital Input/output Pins and PWM Outputs | 14, 6 pins can be PWM | 40 GPIO Pins |
| Memory | 32 KB Flash Memory | SD Card |
| Processor | ATmega328P | Quad Core ARMv8 |
| CPU Speed | 16 MHz | 1.2 GHz |
| USB Ports | 0 | 4 |
| Price | $24.95 | $39.95 |
| Connectivity | Needs attachments for Bluetooth, Wi-Fi, IR, and RF | Bluetooth and Wi-Fi connectivity included. Attachments for IR or RF needed. |

**Table 1**: Parallel Comparison for Processing Technology

| Criteria | Arduino Uno | Raspberry Pi 3 |
|---|---|---|
| Analog Input | 3 | 1 |
| Digital Input/Output pins | 2 | 3 |
| Memory | 2 | 4 |
| Processor | 3 | 5 |
| CPU Speed | 3 | 5 |
| USB Ports | 0 | 5 |
| Price | 5 | 4 |
| Connectivity | 2 | 4 |
| Total | 20 | 31 |

**Table 2:** Decision Matrix for Processing Technology

## 4. Future Work

**Development of tools to connect a specific set of tools (e.g., pumps, displays, phones)**

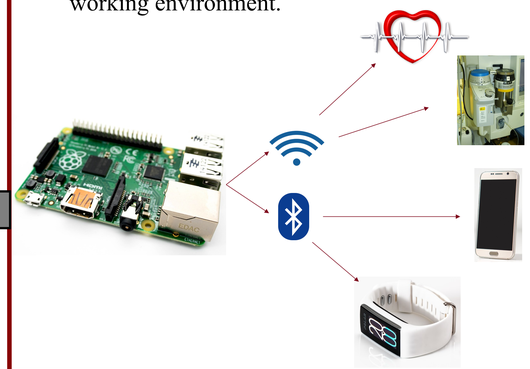
- There is a wide range of sensors and devices that can be used with microcontrollers or SBCs.
- Customization of tool to target a particular problem (e.g., interruption mitigation).

**Reduce interoperability problems**

- Centralize information from multiple devices into one

**Reduce the complexity of medical tasks to improve performance**

- Human-centered designed tools to aid diminish the complexity of tasks healthcare practitioners conduct
- Benefits range from the reduction of medical errors and improvement of the quality of working environment.



## 5. Sources

Sasangohar, F., Donmez, B., Easty, A. C., & Trbovich, P. L. (2015). Mitigating nonurgent interruptions during high-severity intensive care unit tasks using a task-severity awareness tool: A quasi-controlled observational study. *Journal of Critical Care*, *30*(5), 1150.e1-1150.e6.

Sasangohar, F., Donmez, B., Easty, A., Storey, H., & Trbovich, P. (2014). Interruptions experienced by cardiovascular intensive care unit nurses: An observational study. *Journal of Critical Care*, *29*(5), 848–853. https://doi.org/10.1016/j.jcrc.2014.05.007