**Illya’s Project Proposal**

1. Introduction and Objectives
   * General problem or issue to be addressed

University curriculum emphasizes the theoretical aspects of a subject with homework drills to reinforce the lessons. The theory must be learned to earn the degree but often graduates are lacking practical experience needed to compete for, or even how to approach, real-world engineering job situations solving real-world problems.

On the job experience, on the other hand, overemphasizes the practical aspects of getting things done, with schedules and deadlines to track predictable progress along a predictable roadmap. The product must ship predictably in order to pay the bills, but often these predictable methods lead to predictable products lacking any real differentiation in a crowded marketplace.

This project strives to bridge the gap between theory and practice with an open-source hardware and software platform to explore and learn how the two sides, the theoretical and the practical are, in fact, inseparable and should be studied together as a whole.

* + Historical or theoretical context

This project can be related to the Arduino project. The Arduino project originated in 2005 in Italy and was intended for students at a design school to learn and explore basic embedded processing and the interaction with the physical world using sensors and actuators. It has grown into an enormously successful open-source system, taking on the proportions of what is often called an ecosystem. The Arduino system is low cost and easy to use. Anyone can create devices which interact with their physical environment using [sensors](https://en.wikipedia.org/wiki/Sensor) and [actuators](https://en.wikipedia.org/wiki/Actuator) to do interesting and useful things. Other similar systems have also been established. The market of third party vendors offering diverse accessories has also grown significantly.

* + Most relevant previous research and development (R&D) on the topic

The subject is not new. The area of study is formally called: “Physical Computing” and is generally a thriving topic these days. Everyone knows about robots and that is one very prominent application, but that is only one of so many. It seems truly impossible to exhaust the ever-growing variations of applications. This project parallels that success and thus available resources can be utilized to build on what already exists rather than reinventing. The hardware and the software are both open source and available to all and need not be any barrier of entry.

The integration of high-level Linux software and low-level electronics has been a paradigm shift in embedded systems development. This is the point that differentiates this project from simpler types of controllers which can only run a compiled C executable, such as Arduino-like platforms. With Linux there is real computing power and the application horizon expands significantly.

Single board computers running Linux distributions, such as the Raspberry Pi or the BeagleBone, have been available for some time. With every newly released revision, the computing power and sheer capability of these pocket computers continues to amaze. Meanwhile, we have reached a point where the compute resources available in these palm-size computers is adequate to support a high level abstracted programming language. This makes it even easier to develop applications.

* + Project’s objectives

The objective of this project is to create a working prototype which demonstrates the platform feasibility. The intent is as a seed project to build on and for further exploration into the field of physical computing. Since the hardware and software are readily available for free, or at very low cost, it is hoped that a class can be developed and offered at UNH Manchester in which students learn to create physical computing projects. Perhaps ‘Physical Computing’ would serve as an apt name for the class.

1. Approach or Methodology
   * Methods, procedures, or theories that will be used to address the R&D topic

As we consider the interaction with the physical world, such as measuring temperature, to acquire data results from a temperature sensor once every second almost any microcontroller will do, such as an Arduino. Not to disparage the Arduino, it is simple and intended that way and often life is perfectly good that way. However, as acquisition speeds and resolutions of data points increase, in other worlds the complexity of the application increases, the data through-put increases and then increasing processing power is required to support the application. Expanding further along these lines, being able to compute or display results will require even more processing power. Running embedded Linux requires more yet still. One might also want to control lab bench instruments for special data acquisition scenarios, where comparative measurement to known physical standards might be the application. There are also the practical considerations: price, availability, user base, minimal required accessories, less cables, ease of use, etc.

* + Sources, tools, data sets, or practices that will be studied in order to pursue the project

The following software tools are planned to be studied and used in this project:

* KiCAD – A PCB layout software, was created in 1992, will be used for developing the hardware
* Linux – running on the BeagleBone AI pocket computer
* Python – used for all code development work
* Jupyter Notebook – a browser based interactive computing environment. Notebooks are essentially documents which combine live code, interactive widgets, plots, explanatory text, equations, images, web links, and even video.

The following hardware is planned to be studied and used in this project:

* BeagleBone AI single board computer, which is open source hardware.
* Custom cape to interface sensors with the BeagleBone AI
  + Foreseeable challenges or obstacles and how they will be addressed

Jupyter Notebook runs in a web browser. The most fundamental challenge is whether the BeagleBone AI pocket computer has the processing power to smoothly run the server.

A custom Linux distribution could be developed to alleviate some of core processor’s burden by only including needed code modules, but that would exceed the framework of this project. It would be a project in itself. Nevertheless, recommendations for further steps to refine and improve the project, which would surely lead to other potential projects, can and will be suggested.

To this day, C and/or C++ are still the most common embedded programming languages because of the performance and cost optimization. For exploratory, learning and development purposes however, Jupyter Notebook has great advantage. It increases programming abstraction and the interactive document nature can provide a very clear overlook of the concept or algorithm intended, not getting bogged down in details of programming grammar. This leads to increased programming productivity. The tradeoff between the intuitive clarity for humans and the strict accuracy for raw compute power are no longer so strictly mutually-exclusive. Cython is written in C and integrates many C libraries and can be compiled from within the Jupyter Notebook. Wherever practical, the more productive Python-based environment can be used, and whenever efficiency is needed, lower-level C code libraries can be called.

1. Significance and Implications
   * Contribution of the project to the problem and the field of study

To my knowledge, the Jupyter Notebook is not yet being run on the BeagleBone AI. But that is not wherein the glory lies. A physical computing platform based on the BeagleBone AI would be a highly useful contribution in the form of a tool, the field of study itself is left to the imagination.

* + Wider implications of the project R&D (social, cultural, theoretical, etc.)

The intent is that this project will open new doors at UNH Manchester and the material will be used as a basis to develop a class in physical computing or data acquisition. There is a veritable gold mine out there in open source hardware and software, virtually free for the taking.

This is an open-source project that can be expanded to work on any computing platform and any operating system. The choices made as far as tools and materials were necessarily subjective or downright expedient.

1. Outcomes
   * Contribution of the project to the student’s educational goals and how this project will enhance understanding of the field

This project strives to bridge the gap between theory and practice with a laboratory-driven approach to physical computing. Experimentation and learning becomes low-cost, easy, and fun and therefore it will tend to happen naturally.

* + Contribution of the project to the student’s long-term career goals

Most industrial data acquisition systems are overly conservative to their own detriment. That usually means they are very expensive, they use bloated software of questionable stability needing constant updating and they have very little agility to make changes or to perform quick experiments. Many of the supporting engineers pride themselves on being able to “figure it out” and keep the old machine running. This project challenges that status quo. A long term goal would be to support and encourage the growth of this type of embedded data acquisition system. This only mirrors the trend in the electronics industry towards agile embedded IoT, which is sometimes the very product being tested by those antiquated industrial data acquisition systems!

* + Tangible product(s) of the project

A working data acquisition system, both hardware and software.

1. Location
   * Principal location of project work (school, lab, sponsoring organization)

The principle location of project work will be at home and the principle operating hours will be evenings and weekends.

* + Any other research or source locations to which the student will travel

There are neither plans nor any necessity for travel. All materials needed to complete the project are either already on hand or will be easily procured within the development of the project, as needed. Software resources can be downloaded from web portals and hardware can be acquired through normal electronic component distribution channels.

1. Preparation and Experience
   * Preparation and qualification to undertake the project (coursework, job experience, other R&D experiences)

This project is the Masters Project and all the prerequisite coursework to be able to enroll in the project class has been met. Extensive work experience in data acquisition system design and implementation would be another qualification to undertake the project.

* + Plans to further prepare before undertaking the project

No further preparation is perceived necessary before undertaking the project. The approach is relatively clear and work has already begun.

In the course of working the project, various references will be used so as to prepare a better approach to the outcome and to learn new techniques.

* + Faculty advisor and project committee members: names and qualifications
* Prof Tim Chadwick: Faculty advisor
* Prof Chris LeBlanc
* Prof Mihaela Sabin
* Any other…?

1. Timeline

Suggested:

Abstract:           Sept 17  
Proposal:          Sept 21  
Committee Pick:     End of Sept  
Mid Semester Report:  Ongoing weeklies  
Report 1st Draft Due: Week of Nov 15  
Supporting Artifacts: Dec deadline

Demo/Presentation: Week of Nov 15