

**CG4002 Embedded System Design Project**

August 2021 semester

**“Dance Dance”**

**Design Report**

<Think about how to split your team into who will be taking care of specific components, and whether you want subteams, e.g. hw, comms, sw. It is also a good idea to have a nominal team/subteam lead. Throughout the design report, indicate clearly who will be working on which part of the project individually, as well as who wrote up which sections of the design report. For sections that are joint work, such as Sections 1 and 2, indicate so.>

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| --- | --- | --- | --- |
| Group **XX** | Name | Student # | Specific Contribution |
| Member #1 |  |  | Hw Sensors |
| Member #2 |  |  | Hw FPGA |
| Member #3 |  |  | Comms Internal |
| Member #4 |  |  | Comms External |
| Member #5 |  |  | Sw Machine Learning |
| Member #6 |  |  | Sw Dashboard |

The main aim of this report is to **explain your ideas and designs.** Make sure the reviewers have enough details to give you feedback and advice.

The report will be graded based on:

1. Quality of information.
2. Quality of design: Clearly thought out, Feasible, Easy to manage etc.

**Section 1 System Functionalities**

Describe the intended system functionalities**.** It is important to let us (the reviewers) have a clear idea of how the system functions from an external viewpoint (i.e. the user viewpoint).

You can use any of the following:

* Use case diagram with use case description
* Feature lists
* User story

Note that you are not limited to the above options.

**Section 2 Overall System Architecture**

Please give:

1. Use a UML deployment diagram or similar to illustrate the high level system architecture of the intended system. Among other things, indicate clearly:
   1. What do you intend to implement on the Beetle and the Ultra96.
   2. The communication protocol between the Beetles, laptops, Ultra96 and evaluation and dashboard servers.
   3. All hardware components in your design and how they are interfaced with the Beetles and Ultra96.
2. Description / drawing of the intended final form of the system, i.e. as a wearable shirt, vest etc. Try to indicate the placement of the hardware components if possible.
3. The main algorithm for the activity detection problem. Start with a 4-6 major steps algorithm then briefly elaborate how to accomplish each step (e.g. what known algorithm to use, what hardware component plays a part, if machine learning is used, how training data is gathered and used etc).
   1. If appropriate, give a UML sequence / collaboration diagram.

**Section 3 Hardware Details**

**Section 3.1: Hardware sensors**

Please provide:

1. Clear identification of components/devices (part numbers), as well as the supporting components required to get them to work, such as resistors and capacitors. Attach / give links to the datasheets.
2. Pin table: Which pins/interfaces of Beetle/Ultra96 will be used, and how the various components/devices are connected to these pins.
3. Schematics: How will you be connecting the various components?
4. Operating voltage level and current drawn by each component/device, and how your design takes care of these requirements.
5. Some idea of the algorithms / libraries you would be using to get these hardware to detect the start of a move and/or other functionality (including links), or if you are writing own code, the relevant registers and configuration commands.

**Section 3.2: Hardware FPGA**

1. Describe Ultra96 synthesis and simulation setup
2. Detail how the specified neural network model will be realized on the FPGA board
3. Detail how you will be evaluating the design’s timing, power and area with the given dataset.
4. Describe potential optimizations of your neural network accelerator
5. Discuss power management of Ultra96 CPU+FPGA

**Section 4 Firmware & Communications Details**

**Section 4.1 Internal Communications**

1. Describe how you will be managing task(s) on the Beetles, and threads/processes on the laptop
2. Detail how you will setup and configure the BLE interfaces
3. Show a detailed protocol on how you intend to coordinate between the Beetles and laptop: Detail the handshaking, packet types, packet format, baud rates.
4. Discuss how you will handle reliability issues.

**Section 4.2 External Communications**

1. Detail how you will communicate between Ultra96 and the evaluation server. Explain when and how secure communications is ensured. Detail message format, encryption protocol, library APIs you will be using.
2. Detail how you will communicate between laptops and Ultra96.
3. Describe your clock synchronization protocol and how you will leverage it to estimate synchronization delay between dancers.

**Section 5 Software Details**

**Section 5.1 Software Machine Learning**

Please give:

1. How will you be segmenting the sensed data?
2. What features will you be exploring?
3. Which machine learning models will you be exploring, and how will you select and optimize the specific machine learning algorithm? Indicate at least 2 machine learning models, one of which should be a neural network (to dovetail with FPGA acceleration of neural network)
4. How will you train the model?
5. How will you validate and test your model?

**Section 5.2 Software Dashboard**

1. Describe your dashboard design and the analytics you will support
2. Detail how you will be storing the incoming sensor data
3. Explain how you will tackle real-time streaming
4. Detail the user survey you will be conducting

**Section 6 Project Management Plan**

Give a brief timeline (weekly will do) of your internal deliverables and milestones. Indicate who will be working on which milestones and deliverables. Try to align with the evaluation timeline to make sure you have enough time to meet all class requirements. Gantt chart or similar is a good way to summarize your plan.

**Section 6 Societal and Ethical Impact <Only for Final Report ☺>**

This is where you get to dream big and discuss potential societal implications of your project!

How can your dance detector be generalized to other forms of activity detectors, and used for greater societal impact? How will activity detector systems impact ethical concerns, for instance privacy? How can such concerns be balanced? Go wild! ☺

**References**

Please ensure that you cite and list \*all\* references that helped you in your design here.