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Capstone Project Proposal (Week 2 Draft)

Robotic Air Hockey System  
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Capstone Project I - EECE74125

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# Introduction (David)

o Purpose: identify the purpose and audience of the document.  
o The Project: name and briefly describe the proposed project.  
o Background  
‒ Identify what problem the project will solve.  
‒ Specify why this problem needs to be solved.

# Literature Review

## Electric Motor Types and Applications

<https://learn.sparkfun.com/tutorials/motors-and-selecting-the-right-one>

<http://www.nmbtc.com/brushless-dc-motors/why-brushless-motors/>

Electric motors may be used in this project to control the movements of the air hockey paddle. There are several different types of electric motors, each with their own characteristics that make them suitable for specific applications. Literature discussing the pros and cons of brushed and brushless DC motors, stepper motors, and linear motors was reviewed and is summarized below [reference number].

**Brushed DC Motors**

Brushed DC motors are very popular and are used in a wide range of applications. These motors are affordable, simple to control, and output high torque at low speed. Brushed DC motors may not be suitable for all applications as the brushes wear out over time, can generate electromagnetic noise, and have limited speed due to brush heating.

**Brushless DC Motors**

Brushless DC motors are becoming more popular as cheap microcontrollers have made it possible to control them in a wide range of applications. These motors are more efficient and reliable than brushed DC motors, and can achieve higher speeds. Brushless DC motors are more difficult to control than Brushed DC motors.

**Stepper Motors**

Stepper motors are commonly used for position control as they do not require an encoder which makes them very simple to use. Stepper motors are highly commoditized and are very reliable as they do not use brushes. Stepper motors are limited in top speed due to small stepping distances and may miss steps under high loads resulting in incorrect position measurements.

**Linear Motors**

Linear motors eliminate the need to have a mechanical device convert rotational motion to linear motion resulting in low friction and therefore higher speeds. Linear motors only have one moving part so they are very reliable and simple to maintain. Linear motors are very expensive as they are usually purpose built for each application and require custom controllers.

**Comparison of motor types (Thomas)**

* + <https://learn.sparkfun.com/tutorials/motors-and-selecting-the-right-one>
  + Brushed DC motor
    - Pros: Cheap, high torque at low speed, simple control
    - Cons: Brushes wear out, limited speed due to brush heating
  + Brushless DC motor
    - Pros: High speed, more efficient
    - Cons: Difficult to control, requires low starting loads
  + Stepper motor
    - Pros: High position accuracy without requiring encoders
    - Cons: Limited top speed, missing steps under high loads, inefficient
  + Linear motor (unrolled brushless motor)
    - Pros: High speed, efficient, no rotary to linear mechanical conversion required
    - Cons: Expensive, difficult to control, not available off the shelf (custom design for each application)

o Survey on existing solutions for this problem (citation of authoritative  
source required. Authoritative source includes well-known  
technical/scientific journals, magazines, industry white papers,  
product descriptions from original vendor).  
o Compare your solution to existing solutions

* **Examples of existing air hockey robots**
  + Thomas
    - 3D printer parts + Linux box for object tracking & control strategy (<https://www.jjrobots.com/air-hockey-robot-a-3d-printer-hack/>)
    - 3D printer parts + Android phone for object tracking & control strategy (<https://www.jjrobots.com/the-open-source-air-hockey-robot/>)
* **Methods for tracking objects**
  + David
    - Magnets (<http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=7496898>)
    - Vision (<https://pdfs.semanticscholar.org/25a6/c5dff9a7019475daa81cd5a7f1f2dcdb5cf1.pdf>), (<http://www8.cs.umu.se/education/examina/Rapporter/SannaAgrenFinal.pdf>)
    - Ultrasonic (<https://www.allaboutcircuits.com/projects/create-an-object-tracking-system-integrating-servo-control-with-object-dete/>), (<http://engineering.nyu.edu/mechatronics/summit/SUMMIT2007/group6-Will_Bill/Summit2007Project.pdf>)
* **Air hockey strategy**
  + Stan
    - All about air hockey (<http://www.bubbleairhockey.com/air-hockey.html>)
    - Intercepting objects in motion in two dimensions
      * <https://www.khanacademy.org/science/physics/two-dimensional-motion>
    - Adding energy to the system strategically, etc
      * Trick shots (<https://www.youtube.com/watch?v=T2X73BMKWBc>)
    - Machine learning for playing games
      * <https://blogs.unity3d.com/2017/12/11/using-machine-learning-agents-in-a-real-game-a-beginners-guide/>
      * <https://blog.openai.com/dota-2/>
      * <https://www.techemergence.com/machine-learning-in-gaming-building-ais-to-conquer-virtual-worlds/>
* **Mechanisms for high speed linear position/velocity control (Thomas)**
  + Types of linear actuators: <https://en.wikipedia.org/wiki/Linear_actuator>
    - Electromechanical
    - Hydraulic
    - Pneumatic
    - Piezoelectric
  + Belt driven carriage
    - <https://www.jjrobots.com/the-open-source-air-hockey-robot/>
  + Ball screw mechanism
    - Multiple designs – load mounted on sliding carriage or load mounted directly to end of screw rod
    - <http://www.orientalmotor.com/applications/linear-positioning.html>
  + Pneumatic linear actuator
    - <http://blog.parker.com/know-your-pneumatics-hints-tips-for-specifying-linear-actuators>
  + Hydraulic linear actuator
    - High force, difficult to control
  + Piezoelectreic actuators
    - Small range of motion, high precision, low accuracy (due to hysterises)
* **HMI design & implementation options**
  + David
    - Qt, Python, mobile App, website, etc
    - Building a Good HMI (<https://www.automation.com/pdf_articles/opto_22/2061_High_Performance_HMI_white_paper.pdf>)
    - Qt (<http://www.embeddeduse.com/2014/04/19/why-use-qt-for-embedded-systems/>)
    - PyQt and Rpi (<https://www.baldengineer.com/raspberry-pi-gui-tutorial.html>)
    - Website (<https://www.embeddedarm.com/blog/creating-a-human-machine-interface-hmi-web-application/>)
    - Smartphone (<https://www.controleng.com/single-article/an-iphone-as-your-next-hmi/ee2900d7d9c4382803be2b547c767c87.html>)
* **Communication methods in distributed embedded systems (CAN, ethernet, bluetooth, wifi etc)**
  + Stan
    - <http://www.artist-embedded.org/docs/Events/2010/MoroccoSchool/slides/almeida-rtn-rabat-2010-2spp.pdf>

# Project Description (David)

The proposed project includes the design, integration, and validation of a robotic system capable of playing air hockey against a human player. This project will serve as demonstration of the capabilities of ESE students for the general public. This project will supplement existing marketing videos [2] with a fun, interactive game that can be used at open houses and recruiting events. This project will have a positive impact on the ESE program by increasing the programs exposure both within the academic community, and by providing outward visibility for potential students, employers, and industry partners. This project may also serve as a platform to allow disabled people to play air hockey, or for professional players to train against. **Identify professional responsibility attributes (what does that mean?)**

**How much do they want here? We had a lot of detail in the outline.**

o Describe what the proposed system will be and/or do.  
o Identify what will be achievable after the project is complete that isn’t  
achievable now.  
o Identify project context as adding societal, industrial (business or  
entrepreneur) and/or economic value.  
o Identify professional responsibility attribute(s) such as safety, ethics,  
societal impact and environmental concern.

# Project Feasibility

## Expertise

This project will draw upon much of the skills and knowledge learned in the ESE program including embedded system design, software engineering, control theory, operating systems, and electromechanical systems. This project will require acquiring knowledge in the areas of autonomous control strategies, object tracking methods, and mechanical design. The ESE faculty and online references will provide technical expertise to help complete this project.

o Expertise  
‒ identify the knowledge and skills that are required for successful  
completion of the project  
‒ identify any knowledge must be acquired to complete this project  
‒ identify sources of expertise that are available to help complete this  
project  
‒ identify possible external advisors for this project

## Resources

Successful completion of this project will require regular access to the ESE lab space. This project may also rely on other Conestoga College resources such as the 3D printer and machine shop. This project may utilize open source software libraries. This project may utilize mechanical components based on open source designs. The total budget for this project shall be less than $500 CAD. The Air Hockey table will be donated by one of the group members’ families. Where possible the group will use hardware that has already been purchased (ex: Semester 4 robot controllers). This project may be sponsored by the ESE program as it will have a positive impact on the program by increasing the programs exposure both within the academic community, and by providing outward visibility for potential students, employers, and industry partners.

o Resources  
‒ identify the tools and resources that are required for successful  
completion of the project  
‒ Specify the estimated cost of the project.  
‒ Identify possible sponsors of this project.

# Risk Analysis

Based on the risks we have evaluated in the table below, we have determined that the overall risk for this project is low.

|  |  |  |  |
| --- | --- | --- | --- |
| Risk (Priority Highest to Lowest) | Category | Impact on Project Objectives | Potential Risk Reduction |
| 1. Mechanical design/integration problems | Technical | Unable to control robot motion | -Start mechanical prototyping early  -Leverage group members Mechanical Engineering experience |
| 2. Real-time object tracking problems | Technical | Unable to automate robot motion | -Start object tracking prototyping early  -Leverage proven open-source object tracking solutions |
| 3. Security of project in shared classroom | External | Lack of lab workspace availability.  Potential damage to project hardware. | -Utilize dedicated ESE lab space  -Advocate for continued support of ESE dedicated lab space |
| 4. Catastrophic loss of data | Organizational, external, technical | Schedule delays. | -Utilize source control for all project materials  -Manually back up all data once per week |
| 5. Managing scope creep | Organizational, project management | Schedule delays.  Lack of focus on core features. | -Strictly define scope of project during planning phase  -Additional features shall only be implemented after 100% completion of core project features |
| 6. System sizing incorrect | Technical, performance | Lower than desired system performance. | -Use system level performance requirements to drive component design  -Define system level performance requirements based on real-world data |
| 7. Inexperience with HMI design & implementation | Technical | Less relatable demonstration.  Worse user experience.  Difficult to debug. | -Define user interface features early (see: Managing scope creep)  -Start HMI prototyping early  -Utilize popular GUI implementation solutions |

The risk analysis is a document that describes which risks might affect the  
project. It is part of the Proposal. It includes:  
‒ technical, quality and performance risks

‒ project management risks  
‒ organizational risks  
‒ external risks  
The risk analysis report must include:  
‒ an evaluation of the impact of each risk on the major project  
objectives  
‒ the overall risk for the project  
‒ a list of prioritized risks

# References

Template with examples:  
[1] J. Yick, et al., "Wireless sensor network survey," Computer  
Networks, vol. 52, pp. 2292-2330, 2008.  
[2] Y. E. Krasteva, et al., "Remote HW-SW reconfigurable Wireless  
Sensor nodes," in Industrial Electronics, 2008. IECON 2008. 34th  
Annual Conference of IEEE, 2008, pp. 24832488.  
[3] J. Jones. (1991, May 10). Networks (2nd ed.) [Online access on  
June 14, 2016]. URL: http://www.atm.com,  
For more examples see: http://www.ieee.org/documents/ieeecitationref.pdf  
Note: You may use the built in Bibliography functionality in word. We  
recommend the IEEE 2006 Style.