Functional Specification

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Assignment Evaluation:

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| **Item** | **Score (0-5)** | **Weight** | **Points** | **Notes** |
| **Assignment-Specific Items** | | | | |
| **Functional Description** |  | x3 |  |  |
| **Theory of Operation** |  | x3 |  |  |
| **Expected Usage Case** |  | x3 |  |  |
| **Design Constraints** |  | x3 |  |  |
| **Writing-Specific Items** | | | | |
| **Spelling and Grammar** |  | x2 |  |  |
| **Formatting and Citations** |  | x1 |  |  |
| **Figures and Graphs** |  | x2 |  |  |
| **Technical Writing Style** |  | x3 |  |  |
| **Total Score** |  | | |  |

5: Excellent 4: Good 3: Acceptable 2: Poor 1: Very Poor 0: Not attempted

General Comments:

*Relevant overall comments about the paper will be included here*

1.0 Functional Description

In a nutshell, our project is a digital version of Monopoly. When 1-4 players looking to play our game start up the system, they should be introduced to a main menu where players can set game options, edit user profiles, start a new game or reopen one. Upon starting a new game, players will be shown the game board with all the detailed tiles and Chance/Community cards in the centre, similar to the original Monopoly board layout. Players will place their pieces at the bottom left corner (a starting pad) and throw a pair of wireless dice to start the game. The dice will report their orientation wirelessly to the system. In the beginning, the highest roll will be executed and the motor mechanism in the system will move the corresponding piece as many spaces forward as determined by the dice roll. From there, players will take turns to throw the dice, and the system will automatically move pieces to their next locations. If at any point a player decides to perform a special action such as buying a property or trading with another player, they may do so by navigating to and selecting the corresponding option with the use of a scroll wheel and a button.

2.0 Theory of Operation

The device makes use of the following principles to achieve objectives:

* Vectors are used to represent physical quantities that have a magnitude and direction associated with them. In order to move game pieces around the board, we need to identify and calculate vectors for these pieces in code.
* A current passed through a wire coiled around a solenoid will produce a magnetic field, and such a device is called an electromagnet. We can use these to move metal game pieces around the board on a track.
* A rotating system will experience a force called the Coriolis force, which one can measure with sensors in a gyroscope/IMU. We will use a gyro in our dice, whose measured orientation is then reported to the microcontroller to determine the dice roll.
* Wireless transmitters using Bluetooth/Wi-Fi will be used to communicate between the UART modules of the dice microcontroller and the board microcontroller.

3.0 Expected Usage Case

The expected use case for this product is for a family or group of friends to play a game with it, over the course of approximately 2 hours. The product will most likely be stored in a closet, and played with on an indoor table, therefore the product will be in a cool, dry environment for its entire lifespan. The Digitopoly board is intended to be used in a stationary setting, not moving around on the table except for storage after the game is finished. Digitopoly will be able to be played with at most 4 players, and it will be unusual for any more than that to be interacting with the Digitopoly board at any given time. The iconic nature of Monopoly means Digitopoly’s users will likely span a wide range of ages. Users as young as 4 years old may be playing with our product, and there is no real upper limit to our users’ age. They will likely be familiar with electronic systems such as televisions and smartphones, and we do not anticipate Digitopoly being any more complex than those products, so we can assume our users will have the necessary technical competency to operate the game.

4.0 Design Constraints

4.1 Computational Constraints

The computational constraints of the project as a whole will be:

* Only about 1 MB of flash and 192 KB of RAM is available to us on an STM32F4 micro. Since we have a huge game to implement, we have to be able to reuse code as much as possible.
* There will have to be enough non-volatile storage for all the profiles created by users
* On the dice, we will need to balance power consumption, gyro-sampling and wireless transmission performance on the microcontroller, since the only source of power for the micro will be a very small cell that can fit inside each die.

4.2 Electronics Constraints

At this point in time, our project would require the following:

* A large LCD display for displaying game states and a live Monopoly board, interfaced to a Raspberry Pi via a mini-HDMI to DVI-D connector.
* The microcontroller on each die will have to use SPI or I2C to communicate with the IMU and then send that data wirelessly over Bluetooth or WIFI.
* PWM will be used on the main game board micro in order to drive the stepper motor on the XY plotter in order to move the pieces.
* An amplifier will be required to raise the voltage on the PWM signal due to the high voltage requirement on the motors (stepping from 3.3V to 9V).
* A 120V power supply will be needed to power all the components, including the LCD monitor (where consumption will be highest) and the XY plotter.
* An electromagnet will be used to enable the automatic movement of the game pieces.

4.3 Thermal/Power Constraints

The motors required in the piece-moving mechanism require 8.5V (4.25 W), and are the main power users in our product. All other microcontrollers and peripherals are relatively low power. Due to the young age of some of our users, a maximum operating temperature of 104°F is desired. This will likely require passive cooling (heatsinks) and active cooling (fans). The game board will also have some ventilation built in.

Due to the large power requirements of the monitor, we also need a decent uninterrupted wall power supply.

4.4 Mechanical Constraints

Because the product is likely to be stationary for most of its operation, weight is not an important constraint. Just to be safe, we determined that a maximum weight of 12 pounds is reasonable. In the possible event that it is accidentally dropped, our casing will be designed accordingly to prevent such drop damage. There should also be no exposed wiring or other electrical hazards, which will also be factored into our case design, which will most likely involve the use of insulating material. Waterproofing is not strictly necessary since it will not be exposed to water in its expected use case. Since it would be stored in a closet, we plan to seal the entire casing such that dust doesn’t build up on the inside of the game board. It would be designed in such a way that the outer casing can easily be dusted clean if necessary.

4.5 Economic Constraints

Since there is no digitized board game version of Monopoly that currently exists, we decided to pit our costs against similar electronic board games. We found an electronic chess board with physical pieces for $49.99 from Amazon, a regular Monopoly board with voice banking from Amazon for $30, and an Electronic Battleship from Hasbro for $45. We saw an increase in price with electronic complexity, and in our case we believe our game should be developed with components such that the total cost of one of our boards should not exceed $60, which is on the higher end because of the electronic complexity of the project, in line with product prices that we saw online.

4.6 Other Constraints

*In this section, list any other constraints your project might have.*

5.0 Sources Cited:

“Vectors: Maths for Engineering,” *MathsforEngineering*. [Online]. Available: https://www.mathsforengineering.com/vectors. [Accessed: 29-Aug-2019].

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H. Föll, *7.1.2 A Closer Look at a Gyro*. [Online]. Available: https://www.tf.uni-kiel.de/matwis/amat/semitech\_en/kap\_7/backbone/r7\_1\_2.html. [Accessed: 29-Aug-2019].

Appendix 1: Functional Block Diagram

