TruShuffle

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Dr. Micheal Hegedus
Simon Fraser University
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Dear Dr. Hegedus,

I am writing to submit the Requirements Specifications for the ongoing Combined Shuffler and Dealer project, TruShuffle, as per your request. Enclosed is a comprehensive document outlining the project's requirements, goals and the strategic approach for the development of TruShuffle, an innovative card shuffler and dealer.

The objective of this document is to outline the desired outcomes and strategies for TruShuffle. By analyzing the limitations of current market solutions, we have integrated advanced features to significantly enhance the efficiency and effectiveness of card shuffling and dealing processes.

TruShuffle addresses the shortcomings of existing solutions, optimizing randomness, speed, and addressing concerns such as cheating and card damage. The attached document provides a thorough overview of the project's scope, requirements, and implementation strategies.

We kindly request your expert review of the attached document, as your feedback will be invaluable in refining TruShuffle. We appreciate your continued support and guidance throughout the project, and we are honored to contribute to the advancement of card gaming through TruShuffle.

Should you have any inquiries or require clarification, we are available to discuss any aspect of the project at your convenience. Thank you for your assistance and collaboration. We look forward to the successful development of TruShuffle.

Yours Sincerely,

Chief Communications Officer
Daniel Istifanus

TruShuffle

Requirements Specifications

TruShuffle Combined Shuffler and Dealer

Course: ENSC 405W

Company Number: 11
Date : June 11, 2023

Project Authors:

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1 Abstract

This document presents the comprehensive project requirements for TruShuffle, an innovative card shuffler and dealer. Through meticulous analysis of existing market solutions and their associated limitations, TruShuffle aims to introduce pioneering techniques that facilitate more efficient shuffling and dealing processes.

In addition, potential risks and challenges pertaining to the design and implementation of the proposed solution are acknowledged, along with a corresponding action plan to address any issues that may arise.

The successful outcome of this project holds the potential to revolutionize card gaming by eliminating the prevalent issues of inadequate shuffling and dealing mechanisms, consequently safeguarding cards from damage commonly experienced with prevailing market alternatives.

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5 Glossary

Term	Definition
UI	User Interface
Deal	Proffering a player or players a card or cards
Dealer	Person (or mechanism) that deals
Cut	Separating a deck into two or more separate decks
Hand	The cards a player is holding
PCB	Printed Circuit Board
Sleeved	Card placed in a protective holder (usually clear plastic)
Riffle Shuffle	A technique of shuffling cards where the deck is separated into two halves which are interleaved together
Overhand Shuffle	A technique of shuffling cards where one or several cards are stripped from the top of the deck into the non-dominant hand repeatedly
Deck	A complete collection of cards used for a particular game

Table 5.1: Glossary

6 Introduction

Playing cards have long served as a fundamental element in various games, offering an invaluable means of introducing elements of randomness and diversity. The ubiquity of the standard 52-card deck has ensured its enduring popularity throughout human history, as it continues to be widely utilized in a myriad of games, including board games. This enduring appeal can be attributed to its affordability and versatility as a tangible component, making it an indispensable tool for game enthusiasts in the contemporary era.

The act of shuffling and dealing cards constitutes an essential procedural step in diverse card games, dictated by the specific rules and structure of each game. Consequently, the proficiency in these fundamental skills holds paramount significance across a wide spectrum of card games.

The process of shuffling 52 playing cards with the "riffle" shuffle technique requires repetition seven times [1]. Frequent shuffling in games like *Magic: The Gathering* can slow down gameplay and pose challenges for inexperienced shufflers. "Overhand" shuffling is time-consuming, lacks genuine randomness, and can be exploited for cheating [2]. Applying pressure during shuffling can unintentionally damage cards over time [3][4]. Mechanical shufflers exist but suffer from drawbacks such as card damage, jamming, high cost, or limited functionality [5].

We believe we can design a robust mechanical to ensure randomness, prevent cheating, reduce card damage, and enhance gameplay speed.

7 Background

Decks of playing cards are sets of rigid paper rectangles, usually coated in plastic. They are resistant against damage but susceptible to wear over time. There exist standard playing card decks for use in many games that are very affordable (under $5.00 CAD), but specialized decks for specific games can become very expensive (Average competitive *Magic: The Gathering* decks cost about $250.00 CAD). These cards may also be sleeved, protecting the card itself but complicating shuffling the card deck.

Shuffling is the random rearrangement of playing cards. There are several techniques for shuffling including the Riffle Shuffle, Overhand Shuffle, Casino Wash, and mechanical card shuffling machines. Each method varies in complexity and effectiveness, and requires a different amount of repetitions to achieve a "true random" shuffle. For instance, a riffle shuffle requires 7 shuffles to be considered a truly random shuffle [6] . An overhand shuffle on the other hand requires 10,000 shuffles to be considered the same level of randomness [7].

Automatic shufflers and dealers exist ranging from consumer level to casino level. Consumer level auto-shufflers only perform the simple riffle shuffle function, which not only requires 7 times to be effective, but also aggressively rubs and squishes the cards together, which is very bad for card health. This wouldn't be an issue using cheap playing cards, but when using possibly a nicer set or even card game cards which as previously mentioned can be very expensive, existing shufflers would not be good for the cards. Casino shufflers do properly shuffle the cards, however they cost at least a few thousand dollars for the simplest model [8][9], and are still relatively slow, but can shuffle multiple decks at once.

Automatic dealers that don't require a person to handle the cards cost between 100-200 dollars or more, and are rotating in the middle of a table to be able to deal to all players.

As far as shufflers are concerned, none currently on the market treat cards well and true random shuffles only occur in casino machines costing thousands of dollars. All of these solutions still require human intervention to deal the cards, and current dealers only consist of a rotating design in the middle of a table with players sitting in a circular fashion around the dealer.

8 System Overview

TruShuffle will be comprised of a number of overlapping and connected subcomponents. The following will be included as part of the project:

- Input (for Playing Cards)
- Output (for Playing Cards)
- User Interface
- Separating Mechanism
- Shuffling Mechanism
- Dealing Mechanism

Also very likely to be included will be:

- A power supply (likely a wall outlet connection)
- Motorized components
- A movement or ultrasonic sensor

A conceptual sketch from design discussion of some subcomponents together is as follows, though this should not be taken as a suggestion of design or appearance. Several very different designs are in active consideration:
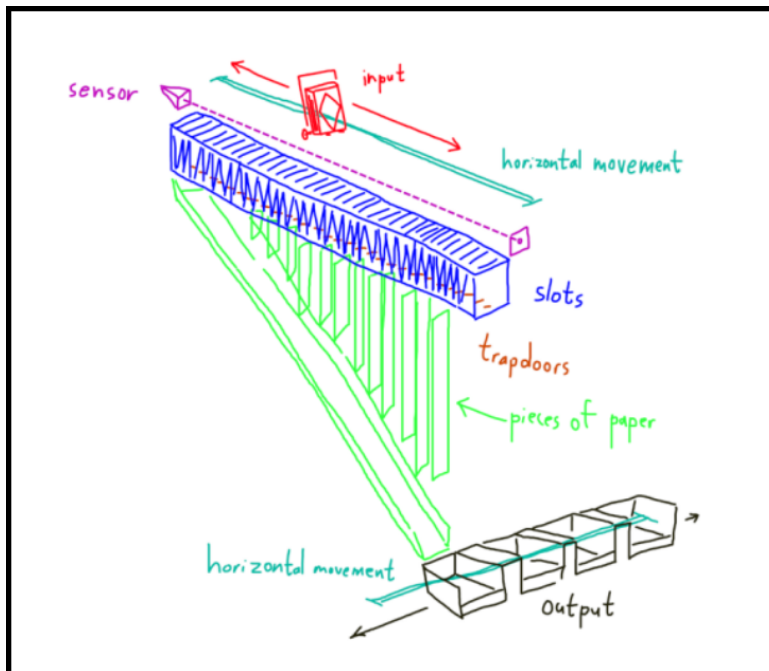

Figure 8.1: Sketch of one design idea

A key aspect of the system is that it should be as *visibly trustworthy* as possible. This means that the target audience (enthusiasts of card games and board games) should be able to know by looking at it that it will not damage cards. For example: cards falling onto a table is a visibly trustworthy situation, whereas cards being fed through gears is not a trustworthy situation. This sense of trust will vary between individuals, but we will attempt to make it as strong as possible given a solution that also fulfills other requirements. The device will implement both this concept of trust and transparency, and also a concept of opacity during actual operation so that the shuffling operation itself can be hidden.

Another aspect of the system is that it should be somewhat size-conscious (i.e. small). We regret that we believe it will not necessarily fit on a tabletop (given our requirements), but we do want the device to be small and sturdy enough to be easily picked up and moved around by a person.

The device is planned to be usable with a reasonable level of speed over repeated uses, such that one could plausibly use it (for example) multiple times over the course of one board game. Currently, the speed at which we will be able to shuffle is unclear, but we are aiming to keep processes under two minutes. Constraining slowness and size to reasonable limits are significant challenges that the project faces.

The device will also have a user interface of some sort, that should be made to be effective, versatile, and intuitive.

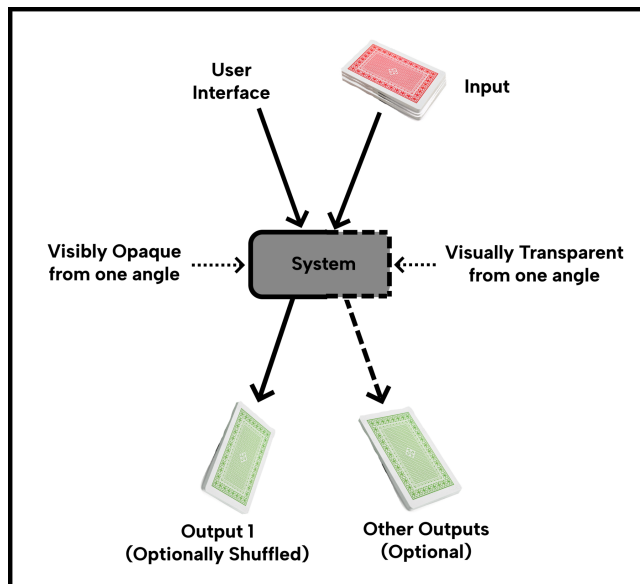A "cloud diagram" of the complete system is as follows:

Figure 8.2: System Cloud Diagram

The system as a whole should be safe for users and surroundings, and implement some level of sustainable engineering concepts, as listed in parts 9.3 and 9.4.

9 Requirements

9.1 Formatting of Requirements

Requirements are divided into several sections:
- System Requirements
- Card Handling Requirements
- Card Interface Requirements (Input and Output)
- User Interface Requirements
- Performance Requirements

Also included in the requirement tables are some "ideal-to-haves", i.e. project aspects that are not absolutely necessary but that are being aimed for; which are identified by a blank in the "Key Item" column.

Also included are sections for Safety considerations, Sustainability considerations, and Standards to be followed.

Requirements are tagged by "stage of completion" in the following way:

Tag	Stage of Completion
A	Proof-of-concept / Engineering Prototype / Production Version
B	Engineering Prototype / Production Version
C	Production Version only

Table 9.1: Stage Labels

This means that every requirement is associated with a given stage of the project, with stage A being the earliest and stage C being the latest. Requirements listed with tag "A" will naturally be expected to be fulfilled at all three stages of the project, and so on.

All requirements are formatted with the following data, and with primary requirements at the top of each list:
- ID (In the format "[requirement type].[requirement number]")
- Tag
- Requirement Description (each entry should be taken to be preceded by "the device should…")
- Requirement Justification
- Requirement Quantification (i.e. test plan)
- Key Item (labeled with X if so, otherwise it is a "ideal-to-have")

9.2 Lists of Requirements

9.2.1 System Requirements

System Requirements are those that apply to the entire system, and not only specific subcomponents. Some requirements that apply to the entire system may also fall under "User Interface Requirements" if the requirement is being realized through the UI.

ID	Tag	Description	Justification	Quantification	Key Item
1.1	A	Be light enough to be carried by the vast majority of people	Ease of use	Reasonable assumptions based on how difficult it is for partners to pick up	X
1.2	A	Be sturdy enough to be transported gently by hand without breaking	Reliability of device	Whether the device regularly needs to be fixed by partners while moving it	X
1.3	C	Be able to suffer minor to moderate knocks without breaking	Reliability of device	Whether the device regularly needs to be fixed by partners while operating it	X
1.4	C	Be "visibly trustworthy"	Design philosophy, safety of cards	Qualitative assumptions based on appearance	
1.5	C	Obscure shuffling process when viewed from at least 180 degrees of surroundings	Usability while playing games	Visual inspection	X
1.6	C	Include short and comprehensible User Manual	Project presentation	Usability by Dr. Hegedus	X
1.7	C	Reset immediately for another use after each use	Speed of use	Using device functions	X
1.8	C	Electronics on PCBs	ENSC 440 requirements	Electrical and Software Testing	

Table 9.2.1: System Requirements

9.2.2 Card Handling Requirements

Card Handling Requirements are those that are related to the quantities and qualities of playing cards being operated upon by the device.

ID	Tag	Description	Justification	Quantification	Key Item
2.1	B	Allow for cards to be easily retrievable if device stops working	Certainty of usability	Retrieval of cards from body of device	X
2.2	B	Be able to handle up to 52 cards	Size of standard deck of cards	Using device functions	X
2.3	C	Be able to handle up to 64 cards	Allows for expanded decks, such as that of *Magic: The Gathering*	Using device functions	
2.4	C	Shuffle with true randomness at least 99% of the time	Sales philosophy	Inspection of process	X
2.5	C	Tolerate cards with maximum dimensions up to 2 cm wider and 2cm taller than standard playing cards	Allowance of decks other than standard playing card deck — broader sales base	Using device functions with larger cards	
2.6	C	Tolerate cards with minimum dimensions up to 1 cm less wide and 1cm less tall than standard playing cards	Allowance of decks other than standard playing card deck -- broader sales base	Using device functions with smaller cards	
2.7	C	Tolerate cards sleeved in plastic, if within allowable dimensions	Broader sales base	Using device functions with sleeved cards	

Table 9.2.2: Card Handling Requirements

9.2.3 Card Interface Requirements

Card Interface Requirements are those pertaining to the users's physical actions of placing cards into the device and retrieving them from the device.

ID	Tag	Description	Justification	Quantification	Key Item
3.1	A	Have an input in which a user can place a deck of cards	Design philosophy	Inspection	X
3.2	B	Have an output that can return cards after an appropriate function has been applied to them (Dealing)	Design philosophy	Inspection	X
3.3	C	Return Cut cards to multiple parties synchronously	Speed of use, appearances	Inspection	
3.4	C	Pass cards to players, rather than having players retrieve them from device	Definition of term "deal", speed of use	Inspection	

Table 9.2.3: Card Interface Requirements

9.2.4 User Interface Requirements

User Interface Requirements are those requirements that relates to what the system does, as accessed through the user interface, or to qualities of the user interface itself.

ID	Tag	Description	Justification	Quantification	Key Item
4.1	B	Have a User Interface that is not uncomfortable to use	Usability	Qualitative considerations from partners	
4.2	B	Have an intuitive User Interface	Usability	User and partner testing	X
4.3	B	Have an option to Cut into up to four decks of equal size	Design philosophy	Testing functions	X
4.4	B	Have an option to Shuffle without Cutting	Design philosophy	Testing functions	X
4.5	C	Have an option to Cut into an arbitrary number of equal piles	Design philosophy	Testing functions	
4.6	C	Have an option to Cut into piles of user-chosen sizes	Design philosophy	Testing functions	
4.7	C	Have a User Interface that is responsive (gives feedback)	Anti-frustration, usability	User Interface use	
4.8	C	Have an option to Cut without Shuffling	Design philosophy	Testing functions	X
4.9	C	Have preset options for one or more specific, popular games	User-friendliness	Testing of options	
4.10	C	Capable of sorting cards	Expanded design philosophy	Testing functions	
4.11	C	Save previous function as default while powered on	Usability	Testing functions	

Table 9.2.4: User Interface Requirements

9.2.5 Performance Requirements

Performance Requirements do not relate to "what the device should do", but instead the "quality and speed at which the device should do it". Requirements that fit this definition and do not obviously fit into other requirement definitions are in this table.

ID	Tag	Description	Justification	Quantification	Key Item
5.1	A	Exact virtually no wear or damage on cards	Design philosophy	Repeated trials with same cards	X
5.2	B	Complete any shuffling or dealing operation in less than two minutes	Usability, design philosophy, expediting gameplay speed	Attempting complex functions	
5.3	B	Have a startup time of less than 5 seconds	Anti-frustration	Turning on user interface	
5.4	B	Have limiting factor in function selection speed be the human, not the device	Anti-frustration	Operating user interface	X

Table 9.2.5: Performance Requirements

9.2.6 Budgetary Requirements

Budgetary Requirements are those relating to the cost of the device.

ID	Tag	Description	Justification	Quantification	Key Item
6.1	A	Cost less to design than the combined available grants for ENSC 405W students	Affordability for partners	Adding up receipts	X
6.2	C	Cost less to mass-manufacture than $300 CAD	Design philosophy, sales	Defined based on assumed reductions from purchases during design	

Table 9.2.6: Budgetary Requirements

9.3 Safety Requirements

Safety Requirements are those affirming that the device will not cause direct harm to humans or to the device's immediate surroundings.

ID	Tag	Description	Justification	Quantification	Key Item
7.1	A	Not have potential to hurt user in regular use	Safety	Visual inspection	X
7.2	A	Have any electrical components shielded from the user	Safety	Visual inspection	X
7.3	A	Not constitute an electrical fire hazard	Safety	Adherence to electrical safety standards	X
7.4	C	Not contain edges that may hurt the user	Safety	Visual inspection	

Table 9.3: Safety Requirements

9.4 Sustainability Requirements

Sustainability Requirements are those relating to potential long term damage caused by the device. These requirements focus on cradle-to-cradle principles, i.e. reduction of waste generated over the lifetime of the device.

ID	Tag	Description	Justification	Quantification	Key Item
7.1	A	Not be constructed from hazardous or environmentally toxic materials	Environmental safety, User safety	Inspection of design materials	X
7.2	A	Have components that can be reset or replaced if they break	Sustainability, long-term reliability	Visual inspection, partner inspection, inspection of design	
7.3	B	Be able to draw from a wall outlet as a power source	Sustainability, user convenience	Use of device	
7.4	C	Be reliable enough that it does not break down	Sustainability, long-term reliability	Non-quantifiable except in the long term	

		over a period of a year		— assumptions made based on parts quality	
7.5	C	Be able to be shut down without unplugging	Sustainability	Use of shutdown function	

Table 9.4: Sustainability Requirements

9.5 Standards

TruShuffle will do its best to adhere to the standards listed below in Table 9.5. These standards are from Standards Council of Canada, Institute of Electrical and Electronics Engineers and Standards Council of Canada.

ID	Tag	Standard	Description
8.1	A	IEC 61190-1-3: 2017	Attachment materials for electronic assembly - Part 1-3: Requirements for electronic grade solder alloys and fluxed and non-fluxed solid solder for electronic soldering applications [10]
8.2	B	IEEE 1801-2018	IEEE Standard for Design and Verification of Low-Power, Energy-Aware Electronic Systems [11]
8.3	C	CSA C22.2 No. 0:20	General requirements - Canadian Electrical Code, Part II[12]
8.4	C	IEC 60065:1985	Safety requirement for mains operated electronic and related apparatus for household and similar general use [13]
8.5	C	CAN/CSA-Z431-12	Basic and safety principles for man-machine interface, marking and identification – Coding principles for indicators and actuators [14]

Table 9.5: Standards

10 Conclusions

The goal of TruShuffle is to redefine the way that shufflers and card games are played. By prioritizing user experience and fairness, the device ensures a truly fair and random distribution of cards, eliminating any concerns of bias or manipulation. Its user-friendly interface makes it accessible to players of all skill levels, allowing them to effortlessly shuffle and deal cards for any game with confidence.

TruShuffle's meticulous attention to card protection ensures that the integrity of the deck remains intact, safeguarding against potential damage or marking. This will be achieved with precision engineering and design, ensuring that risk to card damage is minimized while maintaining the functionality of a shuffler and dealer.

With TruShuffle, we hope to make games even more seamless and enjoyable experiences, empowering players to focus on the strategy and excitement at hand.

11 References

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12 Appendix

12.1 Proof of Concept Presentation

In our proof of concept presentation planned for sometime in August,TruShuffle intends to present:
- Working shuffler that can shuffle cards while not mangling them
- A working dealer that can deal cards according to customizable parameters
- UI interface that can select multiple options for both dealing and shuffling

12.2 Key Problems

The most critical problems that we intend to solve are:
- Separating cards from each other without too much friction
  - Also have to keep in consideration sleeves
- Maintaining card safety throughout the travel of the entire device; before, during, and after sorting and dealing
- Keeping shuffling time within a reasonable amount as to not delay gameplay too much.
- Keeping the design functional enough in size, weight, and cost to be used in generic tabletop settings.
- Making the device user friendly and requiring no prior knowledge to operate