July 30, 2023

Dr. Micheal Hegedus
Simon Fraser University
Burnaby Campus
Applied Science Building, 9872

Dear Dr. Hegedus,

I am writing to submit the Project Proposal for the Combined Shuffler and Dealer project, TruShuffle, as per your request. Trushuffle is a card shuffler that focuses on the safety of the cards and quality of the shuffle, unlike any other shuffler on the market. This proposal will outline the scope, market, risks and benefits as well as the overall planning for this project.

We sincerely invite your expert review of the enclosed document, as we highly value your feedback in enhancing TruShuffle. Your ongoing support and guidance throughout the project have been invaluable, and we are proud to be part of the advancement of card gaming through TruShuffle.

If you have any questions or need further clarification, we are ready to discuss any aspect of the project at your convenience. Thank you for your valuable assistance and collaboration. We eagerly anticipate the successful development of TruShuffle.

Yours Sincerely,

Chief Communications Officer
Daniel Istifanus
Final Project Proposal

TruShuffle Combined Shuffler and Dealer

Course: ENSC 405W

Company Number: 11
Date: July 25, 2023

Project Authors:

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Daniel Istifanus (CCO)
James Lin (CFO)
Kiel Henkelman (CEO)
1 Abstract

This document presents the final proposal for TruShuffle, an innovative card shuffler and dealer, designed to address the limitations of existing market solutions. An analysis of current solutions has guided the development of pioneering techniques to enhance the efficiency of shuffling and dealing processes.

The proposal includes a thorough examination of the risks and benefits associated with the construction of TruShuffle, along with a detailed breakdown of the project's costs. Additionally, the document outlines TruShuffle's expert team and the strategic plan devised to ensure the successful development of the product.

The ultimate goal of TruShuffle is to revolutionize card gaming, by resolving prevalent issues related to inadequate shuffling and dealing mechanisms. By doing so, TruShuffle aims to safeguard cards from damage, a common problem observed with prevailing market alternatives.

Through this professional proposal, TruShuffle endeavors to pave the way for a new era of card gaming by offering a seamless and enjoyable experience for players, while also maintaining the integrity of playing cards. The innovative features of TruShuffle promise to set new industry standards, bringing positive change to the world of card gaming.
2 Executive Summary

TruShuffle presents an innovative card shuffler and dealer, addressing the limitations of existing market solutions through meticulous analysis and pioneering techniques. The proposal includes a comprehensive examination of associated risks, benefits, scope and project costs, backed by a skilled team and a well-defined strategic plan for successful development.

The ultimate goal of TruShuffle is to revolutionize card gaming by resolving issues of inadequate shuffling and dealing mechanisms, safeguarding playing cards from damage commonly experienced with prevailing market alternatives. TruSuffle uses non-intrusive mechanisms, powered by gravity, to minimize potential card damage. True randomization is achieved through a computer algorithm and a specific setup. This professional proposal seeks to usher in a new era of card gaming, providing players with a seamless and enjoyable experience while upholding the integrity of playing cards. With its innovative features and potential to set new industry standards, TruShuffle aims to positively transform the landscape of card gaming, offering a superior and advanced solution for enthusiasts worldwide.
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# 6 Glossary

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<thead>
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<th>Term</th>
<th>Definition</th>
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<tr>
<td>UI</td>
<td>User Interface</td>
</tr>
<tr>
<td>Deal</td>
<td>Proffering a player or players a card or cards</td>
</tr>
<tr>
<td>Dealer</td>
<td>Person (or mechanism) that deals</td>
</tr>
<tr>
<td>Cut</td>
<td>Separating a deck into two or more separate decks</td>
</tr>
<tr>
<td>Hand</td>
<td>The cards a player is holding</td>
</tr>
<tr>
<td>PCB</td>
<td>Printed Circuit Board</td>
</tr>
<tr>
<td>Sleeved</td>
<td>Card placed in a protective holder (usually clear plastic)</td>
</tr>
<tr>
<td>Riffle Shuffle</td>
<td>A technique of shuffling cards where the deck is separated into two halves which are interleaved together</td>
</tr>
<tr>
<td>Overhand Shuffle</td>
<td>A technique of shuffling cards where one or several cards are stripped from the top of the deck into the non-dominant hand repeatedly</td>
</tr>
<tr>
<td>Deck</td>
<td>A complete collection of cards used for a particular game</td>
</tr>
<tr>
<td>USD</td>
<td>United States Dollar</td>
</tr>
<tr>
<td>CAD</td>
<td>Canadian Dollar</td>
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Table 1: Glossary
7 Introduction

Playing cards have been an essential part of various games, providing a valuable way to introduce randomness and variety. The standard 52-card deck's widespread use has kept it popular throughout history, being widely employed in a diverse range of games. Its enduring appeal can be attributed to its cost-effectiveness and versatility as a tangible element, making it an indispensable tool for modern-day gaming enthusiasts.

Shuffling and dealing cards are vital procedural steps in diverse card games, each governed by the specific rules and structure of the game. Proficiency in these basic skills holds significant importance across a broad spectrum of card games.

To shuffle 52 playing cards using the "riffle" shuffle technique, repetition seven times is required [1]. Frequent shuffling in games like Magic: The Gathering, can slow down gameplay and present challenges for inexperienced shufflers. "Overhand" shuffling is time-consuming, lacks true randomness, and can be exploited for cheating [2]. Applying pressure during shuffling can unintentionally damage cards over time [3][4]. While mechanical shufflers exist, they suffer from drawbacks such as card damage, jamming, high cost, or limited functionality [5].

We are confident in our ability to design a robust mechanical shuffler that ensures randomness, prevents cheating, reduces card damage, and enhances gameplay speed.

8 Background

Decks of playing cards typically consist of rigid paper rectangles coated with plastic, providing resistance against damage but becoming susceptible to wear over time. While standard playing card decks used in many games are quite affordable (under $5.00 CAD), specialized decks designed for specific games can be considerably expensive (e.g., competitive Magic: The Gathering decks starting at around $250.00 CAD [16]. Some players opt to use card sleeves to protect the cards, but this can complicate the shuffling process.

Shuffling involves the random rearrangement of playing cards, and various techniques exist, such as the Riffle Shuffle, Overhand Shuffle, Casino Wash, and mechanical card shuffling machines. Each method varies in complexity and effectiveness, requiring a specific number of repetitions to achieve a truly random shuffle. For example, a riffle shuffle necessitates seven shuffles for a "true random" outcome [6], while an overhand shuffle requires approximately 10,000 shuffles for the same level of randomness [7].

Automatic shufflers and dealers are available at different levels, ranging from consumer-level to casino-level devices. Consumer-level auto-shufflers typically perform the simple riffle shuffle, which not only needs seven repetitions but also exerts force on the cards, potentially damaging them. While this might not be a concern with inexpensive playing cards, it becomes problematic when using pricier or specialty card game decks. Casino shufflers, on the other hand, achieve proper shuffling but can cost a few thousand dollars for the simple models
and may still have relatively slow shuffling speeds, although they can handle multiple decks simultaneously.

Decent automatic dealers, which eliminate the need for human card handling, can be found in the market for prices ranging from $100 to $200 or more [17]. These dealers are typically designed to rotate in the middle of a table, ensuring that all players receive cards.

Currently, there are no shufflers on the market that adequately preserve card quality while achieving true random shuffles. Only casino machines costing thousands of dollars can achieve this level of performance. Moreover, existing solutions still require human intervention for dealing, and most dealers consist of a rotating design at the center of a table, accommodating players seated in a circular fashion around the dealer.

9 Scope

The TruShuffle shuffling system is essentially designed to make the possibility of damaging cards as minimal as possible. Current market shufflers push the cards together in a way that cards can be easily damaged. In that sense, our system is more appropriate for customers with delicate or expensive cards, although it can be used by anyone. It also implements a truly random shuffling in one iteration of the system. Shuffling by hand or by common shuffling machines requires at least 7 iterations for a truly random mixing [10]. In addition, the TruShuffle system can deal cards into separate equal piles. The number of piles is chosen by the end user.

The system is divided into 4 subsections (the input mechanism, the central wheel, the output stations, and user interface). A flowchart of the system is shown in figure below:

![Flowchart]

Figure 1: Structure Flow Chart
After the machine is turned on using the power button, a user interface prompts the user to load the cards at the input station. This is followed by the customer entering the number of required equal piles (via the user interface buttons). The system starts pushing down cards from the input mechanism (via a linear actuator), into wheel slots (one by one). This is done by a pushing mechanism sitting behind the cards in a non-intrusive manner. Cards fall into the slots on the rotating wheel. As a card falls, the wheel rotates (via a stepper motor) to the ready position for the next card.

After all the cards have fallen and the wheel is full, the system will start the randomization process and unload the cards at the appropriate output ports. There will be 4 output stations, and depending on the number of piles required by the user, the appropriate output station(s) will start getting filled. The wheel will turn in a randomized fashion and stop at the appropriate piling station. Below every slot of the wheel is a 3d printed swinging mechanism. This mechanism is pushed upon from the bottom by a gearing system that is controlled by a servo motor. The gearing system pushes the bottom of the swing out of the way such that the card is free to fall in the output (piling) station. The output stations are meticulously shaped to overcome any angled orientation of the card. This is done in such a way that by the time the card is at the very end of the output station, it will be positioned correctly.

As mentioned above, this system is essentially non-intrusive and minimizes possible damage to cards. This is done by making use of gravity as much as possible. We also avoid or at least minimize rollers that will directly push on the cards. The pushing mechanism of the input, the swinging slots of the wheel, and the mechanical shape of the output essentially leave the cards free from any direct push and pull.

The true randomization aspect is achieved by using an algorithm to randomly determine which wheel slot will be sent to output. This can be done with one iteration of the system because the cards have no relative positional relation to each other during the shuffling process.

This system as a whole is a safer, more accurate shuffler in comparison to what is available in the market.
10 Risks

Speed of Shuffling
The speed of shuffling could be slow, thus limiting the usefulness of the device. The three separate moving parts of the shuffler must be coordinated in such a way and operate very smoothly together to ensure that the shuffling happens in a timely manner.

Cost of Device
Since the Device currently requires many custom parts manufactured in various ways, the cost of the device initially could be quite high. This should be mitigated with mass production as well as the electronics being more or less much more simple than the design of the physical device itself.

Ease of Use
The device, without a very well designed user interface, would be cumbersome to use. It would also increase the time it would take to coordinate shuffles. The user interface must be carefully designed to ensure that button pressing and navigating is minimized whilst the device is in use.

Fragile Device
The device itself could be unexpectedly unstable with all the moving parts, and would make moving the device difficult if such a task was required. The structure would have to be reinforced or modular enough to either be structurally sound or be modular enough to be disassembled and reassembled safely and securely.

Card Shuffling Privacy
Due to the current design and material choice, the cards could be seen by an observer from the outside. If they were to memorize the locations at which the wheel stops, they could potentially know the new ordering of cards. This would be solved with some privacy structures that would be put in place so that the cards cannot be seen from most angles.

The other aspects of the system that could risk privacy include the physical speed it takes for cards to drop or the sounds that the motor makes. An astute observer could count the timing of the card drops to figure out the ordering through sound. To minimize this, the motor noise should be controlled and algorithms should be varied so these factors are no longer discernible to a human observer.
11 Benefits

Fair Games

This shuffler, as described in previous sections, will complete a truly random shuffle. This would ensure games are fair and unbiased, at least from a card shuffling perspective. It would also remove the ability for a user to botch a shuffle either intentional or unintentionally to further ensure fairness.

Card Safety

The design of the product has a primary focus on card safety. It will ensure that damage to cards is as minimal as possible and that they will retain their original state. TruShuffle is designed to be delicate in its handling and use gravity instead of aggressive rollers and gears. Cards can cost a lot of money, as mentioned previously, and this shuffler would be a one of a kind for those looking to use their prized cards in play.

Assistive for Shuffling

For some, completing a proper riffle shuffle could be difficult. When this is the case, the overhand shuffle is commonly used, which as stated previously is extremely ineffective. The system is also useful for those who have difficulty shuffling (whether due to experience or health related issues).

Possible Profit Increase

An enhanced shuffling speed, surpassing the average shuffle rate, holds the potential to yield substantial profit increments for establishments hosting card game sessions, such as casinos. The ability to accommodate more games within a given timeframe could result in a larger influx of customers to the venue. For casinos, the increased number of hands played directly correlates with amplified profits, making efficiency in shuffling a significant factor in maximizing revenue.
12 Market, Competition, Research Rationale

TruShuffle will join as part of at least one large industry. The board game industry is currently worth approximately $3 Billion USD annually, and is growing rapidly. Worth about $1 Billion USD in 2017, this market is projected to continue expanding explosively to $4.5 Billion USD by 2026. [11] A large contingent of these games include at least some cards as part of their gameplay.

TruShuffle will also join the trading card game industry. This industry is worth more than $6 Million USD, anticipated to approximately double to $12 Million USD by 2033 [12]. The trading card community is large, enthusiastic, and currently has no shuffling solution that will not mangle potentially valuable trading cards, besides shuffling by hand. Because trading card games such as Magic: The Gathering can require frequent shuffling of large decks, this market is the ideal location for marketing the TruShuffle product towards.

The gambling industry is vast. Valued at $702 Billion USD in 2023, it has grown extremely rapidly from $449 Billion USD in 2022. [13] Gambling is an increasingly online business [14], and not all gambling games include the use of playing cards, but it is nonetheless a large segment of TruShuffle’s theoretical market. While this market tends to use cheap, disposable cards, and already makes use of automated (albeit, prohibitively expensive) shufflers, there may be room for interest in our product. A party interested in gambling remarked to our group that our device could serve as a replacement for croupiers at physical tables, potentially saving casinos employee overhead costs. The group has some reservations about ethical concerns in regards to marketing TruShuffle towards the gambling industry, but nonetheless accepts that there may be interest from that industry towards our product, regardless of our personal feelings.

In terms of competition, there are existing shufflers on the market. However, our group strongly feels that none of them are sufficient for the purposes of many potential consumers. Existing shufflers roughly fall into two categories:

- Casino-grade shufflers
- Household shufflers

Casino-grade shufflers are those that can be found inside machines at casinos, or inside of casinos in general. They tend to be very expensive — more than $500 [15], and while it is beyond the scope of this document to list all relevant casino-grade shufflers, including reviews and track records, it is known that they can be prone to jamming, that they are “black boxes”, reducing visual trust, that they will only correctly operate with a narrow range of card sizes, and that they are generally beyond the means of most consumers.

Household shufflers are more affordable for consumers when compared to casino-grade shufflers, however they come with several significant downsides. [5] Again, it is beyond the scope of this document to list every household shuffler in existence, but in general, several things can be said about them. They use either a “vibration” technique to effectively merge two split decks of cards together, or they push split decks together using wheels, meaning the
process is not fully automated, and that, by using a “merge-type” technique, cards are highly vulnerable to being damaged. [5] Savvy consumers are aware that such shufflers are inappropriate for handling cards any more expensive than cheap playing cards, as they are known to inevitably jam and mangle cards. This type of shuffler is not trustworthy in the long or medium-term for enthusiast communities, and so the preferred method for shuffling remains doing it by hand. This type of shuffler also does not deal in addition to shuffling, which is a valuable added-feature that will be a native part of our product.

13 Company Details

Our company name is TruShuffle, and we are the creator of the flagship product of the same name: the TruShuffle solution for shuffling and dealing. We founded this company in May 2023 as part of Simon Fraser University’s capstone programme, with the intent of creating a device that is innovative, has market value, and will make it truly easier to accomplish a certain task: our settled-upon task was shuffling and dealing. Our company team is composed of one Systems Engineering student, Amir Eghbal, and three Computer Engineering students: Kiel Henkelman, James Lin, and Daniel Istifanus. The following are some short bios of our team members:

Kiel Henkelman

Our CEO, Kiel Henkelman, grew up in Squamish, BC, and plans to graduate from Simon Fraser University with a degree in Computer Engineering. He has strong interests in programming, physics, geography, design, and data. He has applied his interests in physics and design to create many of the structural suggestions, diagrams, and documentation for the company. He suggested the TruShuffle product idea as he has trouble shuffling cards, but enjoys board games and card games.
James Lin

Our CFO, James Lin, plans to graduate from SFU with a degree in Computer Engineering. He is greatly interested in software, and game design. These interests assisted greatly in the software and mechanical intricacies of the design of the product. He will work with Daniel to complete the software and programming of the mechanics in the TruShuffle.

Amir Eghbal

Our COO, Amir Eghbal, is a mature student who plans to get a Bachelor’s degree with honours in the field of Systems Engineering from Simon Fraser University. He is interested in the fields of Robotics and Automation. He has mainly focused on the physical Mechanics of TruShuffle as well as providing support to other team members.

Daniel Istifanus

Our CCO, Daniel Istifanus, hails from Nigeria as an international student pursuing a degree in Computer Engineering at Simon Fraser University. His profound interest in Software development, system integration, and analysis has been the driving force behind his involvement in the TruShuffle project. Collaborating closely with James, Daniel is actively engaged in programming the mechanical motors and linear actuators essential for realizing the successful development of TruShuffle.
14 Project Planning

The following is a combined milestone and Gantt chart for this project from the original time the Gantt chart was made for Journal Submission 2 on June 9 to the completion of the project on August 9:

Figure 2: Project Gantt Chart

As can be seen in retrospective, our planned milestones were fairly aspirational. However, our group has successfully completed all critical deliverables correctly and on time, so TruShuffle views this as a misalignment on our part of expectations of when different phases of a project might’ve happened, and when different phases of a project should actually happen. For
example, “Budgets” took nearly the entire length of the project as there were many points in which we had to come up with ways of cutting costs by using cheaper materials or processes after finding out certain techniques or materials were quite expensive.

15 Costs

Included is a breakdown of project costs to-date and an approximate set of costs expected into the future of this project.

Costs To-Date

Electronics:
- Adafruit Motor Shield V2: $29.12
- Jumper cables: $12.32
- Linear Actuator: $131.02
- Female Headers: $13.43
- Servo Motors: $20.15
- Stepper Motor: $22.99
- Power Supply: $15.18
- Flanges: $15.99

3D Printing Costs: $35.00

Tools:
- Small Screw Driver Set: $16.80
- Plexiglass Cutter: $19.53
- Dowel: $1.69
- Grinder cutting wheel: $6.15

Nuts and Bolts and Screws:
- Small nuts and bolts: $2.24
- Large bolt rod + washer and nuts: $15.00

Other:
- Epoxy Glue: $15.67

Total costs to-date: $327.30

Future Costs (Approximate)

3D Printing: $200.00
High Accuracy Stepper Motor: $100.00
Possible other costs: $150.00

Total future costs: $450.00
Total Costs and Funding

The total current expected cost for the TruShuffle project is $777.30 CAD.

The company plans to make use of all funding available to us through school (Engineering Science Student Endowment Fund, Wighton Engineering Development Fund and IEEE Student Project Funding). Any remaining cost we will distribute amongst ourselves. Amir Eghbal has offered to cover the costs of some members and that they could repay him once they graduate and get a job.

16 Conclusion

TruShuffle is a product that we believe has a market. Existing shufflers are not sufficient and do not catch enthusiast consumer interest — they do not deal, they are too expensive, they mangle cards given some length of time. We intend to create a product that solves all of these problems, and serves as an option for enthusiasts to work in tandem with any type of game that involves the use of cards. We hope that many of those who play board games or card games will appreciate the utility of this device.

The TruShuffle team is actively realizing this product at a great pace. Large effort has been made to ensure that the design fulfils all of our specifications, while keeping our costs balance-positive. The manufacturing process is progressing quickly, as a result of the group having put extensive effort into understanding how this device should be designed. TruShuffle has iterated on many different design possibilities in coming up with the upcoming prototype model.

By August 8, 2023, the TruShuffle company will have a working demo to display the basic operation of the device, including all critical components of the solution working together as a single system. Various test plans devised over the course of this project will be used to ensure a high quality demonstration.

In the creation of TruShuffle, we are proud to have come up with a design that will enable shuffling and dealing to be a seamless, simple process, that is perfectly random every time, fully automated, and safe and visually trustworthy for users.
17 References


18 Acknowledgements

We would like to thank Professor Mike Hegedus for providing mentorship, spare components to use, and being our professor in this capstone course.

We would also like to thank Marc Alfonso of PLC Electronic Solutions Limited, and his team, for providing enormous help by allowing us the use of his industrial workshop, including guidance for use of provided tools.

Finally, we would thank Yalda Foroutan, the teaching assistant for this course, for the work she does behind the scenes in keeping this class supported.