Senior Independent Study in Computer Science

Abstracts

2017

Dana Foley

Computer Science and Mathematics major

Monotonic Untangling to Solve the Unknotting Problem
(advised by Nathan Sommer, Computer Science, and Matt Moynihan, Math)

Abstract: In mathematics, a knot is a single strand crossed over itself any number of times, and connected at the ends. The Reidemeister Moves have been proven to be the three core moves necessary to fully untangle a knot. We define a set of generalized moves based on the Reidemeister Moves which only reduce or maintain the complexity of a diagram. We provide a proof that these moves are sufficient for untangling all knots, including hard unknots. Additionally, we construct a computer program which reads the projection of a knot in its Extended Gauss Code notation and uses our moves to untangle it to the smallest number of crossings.

Alex Gould

Computer Science and Physics major

Chaos Dynamics in the Rotation of the Small Moons of Pluto
(advised by Sofia Visa, Computer Science, and John Lindner, Physics)

Abstract: We examine the influence that a binary gravitational source has on the rotation of a non-spherical object around it. This is modeled using a pair of masses connected by a rigid massless rod, and then is simulated on a computer using the CVODE differential integrator. The two dimensional simulations, which lock all movement to a plane, produce dynamics which are unique and distinct from that which a singular gravitational source would produce. In three dimensions, however, the simulation crashes due to numerical errors which result in extreme unphysical divergence, and non-constant energy.

Alex Iudice

Computer Science and Mathematics major

Clear Communication: Construction and Implementation of Error-Correcting Codes
(advised by Denise Byrnes, Computer Science, and Jennifer Bovens, Math)

Abstract: This project delves into the underlying mathematics and applicative computer science of error-correcting codes. A brief overview of error-correcting codes and how they work is proceeded by an extensive look at the Hamming code. Then the mathematics of finite fields and their intimate connection with error-correcting codes is developed and analyzed.
Following this, the applicable side of error-correcting codes are inspected through extensible error-correcting code and noise software created for this project.

**Conor Maley**

*Computer Science and Mathematics major*

**Evolving Monkeys into Sharks: An Analysis of Daily Fantasy Football Drafting Strategies**

*(advised by Sofia Visa, Computer Science, and Drew Pasteur, Math)*

Abstract: The Daily Fantasy Football Sports industry has recently skyrocketed. Led by powerhouses FanDuel and DraftKings, the industry is estimated to be worth over a billion dollars. The games themselves have been declared “skill games,” meaning there is an underlying strategy behind Daily Fantasy Sports. This anomaly can be seen simply by the fact that only a few top players typically win most of the cash prizes. In this project we provide a deep exploration into the data science that lies behind choosing a team in Daily Fantasy Football. With team salary restrictions, Daily Fantasy Sports present an interesting optimization problem: users must make difficult decisions on which players to play on a given week. We investigate these decisions using analytics and machine learning to both model and analyze past data. The main goals of the investigation are to gain a better understanding of what statistics best predict player performance and find how we can produce the team to give contestants the best chance to profit. Through the investigation, we present our findings on the impact of past player performance, salary cost, and past opponent performance on a player’s future performance. Finally, we develop models to choose teams based on these statistics and evaluate the models in a simulated Daily Fantasy Sports environment.

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**Avery Rapson**

*Computer Science major*

**Grasping the Void: Immersion Tactics Using Gesture Controlled Physics in Interaction Systems in Virtual Reality**

*(advised by Denise Byrnes, Computer Science)*

Abstract: This thesis uses the HTC Vive in Unity to compare two different types of object interaction systems in order to determine the effectiveness of physics based interaction systems in a virtual environment. There is no standardized method for defining successful object interaction techniques in VR. There are numerous interaction techniques in VR that fall short of simulating realistic object interaction. This project explores a physics base interaction system and examines how effective it is by comparing it to a non-physics based system. A model house with various intractable objects is created to compare the two interaction systems. The first system, the naive interaction system, parents an object to the
controller model, allowing the user to pick up and throw things in a very simple fashion. This system is compared to a physics based Newtonian system that takes into account mass and velocity during object interactions. The Newtonian system promotes a much deeper sense of immersion for a user due to how accurately the system simulates real life physical interactions. It is clear that creating a high level of mental and physical presence is crucial for a VR experience. Object interaction systems are an integral component of a VR experience that directly contribute to the realism and levels of virtual presence that a user achieves with a virtual environment. The results conclude that physics based interaction systems provide levels of realism and immersion that the naive systems cannot achieve. The results are beneficial because they demonstrate the positive impact that physics based interactions systems have on a VR experience and the need for improved systems in the future of VR development.

John O’Neill
Computer Science and Political Science major
A Machine Learning Approach to Understanding Against Party-line Voting in Congress
(advised by Sofia Visa, Computer Science, and Bas van Doorn, Political Science)

Abstract: For the majority of votes that take place in Congress, over 90% of legislators’ votes can be explained by pure ideology. In years when no party has a significant majority, party unity becomes imperative in the scope of advancing the party’s agenda. Various theories seek to explain congressional voting behavior as a catch-all approach, and often fail to further our understanding of the inconsistencies in voting behavior. Our lack of understanding of against party-line voting hinders our ability to explain and predict voting behavior. This project seeks to utilize various machine learning techniques to gain a better understanding of what causes against party-line voting in Congress.

Zach Phillips-Gary
Computer Science and Philosophy major
Are Virtual Things Real? An Investigation into the Nature of Virtual Reality
(advised by Denise Byrnes, Computer Science, and Elizabeth Schiltz (Philosophy)

Abstract: Situated within the context of interdisciplinary research, this thesis leverages concepts from the fields of metaphysics, experimental psychology, game design and human-computer interactions to answer the question “are virtual things real?” First we attempt to develop an ontological account of virtual entities, using as a starting point the framework proposed by philosopher David J. Chalmers in his 2016 talk, The Virtual and the Real. We then expand on Chalmers’ account using concepts from Husserlian phenomenology in order to describe the first-person phenomenal experience of virtual reality. Next, we demonstrate that our modified version of Chalmers’ thesis is compatible with several major contemporary ontological accounts of the universe (materialism, idealism, and property-dualism). Using this framework, we present a series of “rules of thumb” for designing virtual reality environments with a realistic feel. Next we describe a series of empirical non-technical virtual environment design factors confer a phenomenal experience of realism upon the user. To conduct these experiments, we designed and implemented a series of virtual environments, along with an automated data collection system to measure in real time the qualitative variables analyzed in the study. Concurrently, we utilized phenomenological techniques to better understand whether these variables map on to the subjectively experienced of realism many participants experience inside immersive virtual worlds. We then describe the implementation of the software using the Unity3D game engine and the technical background of the HTC Vive virtual
reality hardware employed in the experiments. Finally, we report the results of the empirical experiments and comment on the data collected. Although the quantitative analysis of the data from the automated data collection system failed to yield any statistically significant results due to issues with experimental design, the qualitative study seems to demonstrate an empirical grounding for our claim that virtual things are real in an ontological sense.

Lewie Roberts

Computer Science major

Jack In: An Exploration of Immersion in Virtual Environments
(advised by Denise Byrnes, Computer Science)

Abstract: Within the last few years virtual reality has quickly become more popular and available to a larger number of consumers. As this technology grows in popularity, one of the features that will define its usefulness is its ability to convey immersion. This project examines what makes virtual environments feel immersive to users. Different styles of movement in virtual environments are examined. Sensory feedback is discussed in an investigation of how our senses convey presence. Environment design is also examined, with a focus on the spaces of two virtual environments, which are tested on users who provide feedback as to what did and did not feel immersive. By the end of this paper, the reader should have a better understanding of how virtual environments are created as well as what affects our feelings of immersion within them.

Nan Jiang

Computer Science and Mathematics major

Building a Course Recommender System for The College of Wooster
(advised by Sofia Visa, Computer Science, and Robert Kelvey, Math)

Abstract: The goal of this project is to investigate the approaches for building recommender systems and to apply them to implement a course recommender system for The College of Wooster. There are three main objectives of this project. The first is to understand the mathematics and computer science aspects behind it. The mathematic concepts built into this project include probability, statistics and linear algebra. The final products consists of two components: a collection of Python scripts containing the implementation code of the course recommender system, and a simple user interface to analyze the pros and cons of different approaches by comparing their performance on the same training data sets which have information about students and courses at the College in the last seven years. The final goal is to apply the best model to build the course recommender system that can provide helpful and personalized course recommendations to students.

Yunjia Zeng

Computer Science and Mathematics major

Modeling Double Major Data and Predicting Organic Chemistry Grade at The College of Wooster
(advised by Sofia Visa, Computer Science, and Drew Pasteur, Math)

Abstract: This is a data driven independent study. Using the data provided by the registration office of The College of Wooster, we (1) analyze the data related to the double major students to make a double major network, and (2) predict the grade in the organic chemistry class using information about previous taken classes. By analyzing the double-major network using random walk and Markov chain methods, we observe that STEM majors are more connected than the rest of the majors. By using multi-linear regression and pattern recognition neural networks for predictive modes of the students’ grades in organic chemistry class, we figure that the prerequisite, the accumulated GPA and the highest math class that a student completed are predictive to their organic chemistry grades.
Abstract: This project seeks to incorporate augmented reality (Microsoft Hololens) with geometry. It provides a platform for users to build 3D math graphics in Holograms and offers a new perspective for the users to feel and learn 3D graphics. The development of this application will be based on Unity and will use C# as the main programming language. Also, we will use Visual Studio with the Windows 10 SDK, and the Hololens Emulator, which is used for simulating the scene in a real Hololens. The expectation of this project’s final version is that the users can input an implicit function in script. The program generates corresponding graphics which is an .obj file. Users can import them into the Hololens to make the graphics shown as holograms. Users are also allowed to interact with the holograms by zooming and spinning.