Student Component (email to your faculty mentor)

Student Data sheet

Project Title: Using Artificial Intelligence and Game Theory to Improve Balance in Game Design
Faculty Mentor name: Albert Xin Jiang

Student name: Shiyu Liu
Student ID: 0809639
Email: sliu@trinity.edu
Telephone (Campus and Cell): 210-374-5222

GPA: _____3.76_____
Graduation expected in May __ December _ √ _ of 2018 __ 2019 __ 2020 _ √ _ 2021 __
Note: Summer Undergraduate Research Fellowships are not available to students who will be graduating before the completion of the fellowship (May, 2018).

Major or intended major: _____Computer Science & Economics_____
Academic Advisor: _____Mark Lewis_____

Are you a: McNair Scholar? ___ FASTER grant recipient? ___
Semmes Distinguished Scholar? ___ TU Top Scholar? ___
Beckman Fellow? ___
Have you previously received a Summer Undergraduate Research Fellowship? If yes, which program? _____

Check all of the summer opportunities that you have applied for or intend to apply for.

__ √ __ Murchison
____ Biology (BSURF)
____ FASTER research award
____ Environmental Studies (Hixon)
____ Individual Faculty Grant (Professor's name _____)
____ Off-campus research opportunity
____ Summer Internship or Job
____ Mellon
____ Chemistry (Welch departmental)
____ Geosciences

Name and email address of TU faculty member who has agreed to submit a letter of recommendation.

_____

Optional:

Sex: Male _ √ __ Female ___ Race/Ethnicity: _____
Citizenship: U.S. citizen ___ U.S. Permanent Resident ___ Other _ √ __
Pell Grant eligible: yes ___ no _ √ __

1st generation (neither parent completed a 4 yr degree) ____

Student Statement (200 word limit)

Project Title: Using Artificial Intelligence and Game Theory to Improve Balance in Game Design
Faculty Mentor name: Albert Jiang
Student name: Shiyu Liu

Please describe your motivation for participating in *this* summer research project. What are your career goals? How will this research project aid in reaching your career goals?

Coding is always challenging but fun to me. I have been a game enthusiasm: my dream was always to be a top skilled programmer and devoted myself to the gaming industry. When you look at American video games companies like naughty dog and Rockstar gaming, and when you see companies like Atlus and Sega, they could accomplish so much with their creativity and skills. I even learned economics so that someday in the future, I could start my own game studio.

But simultaneously, I realized some games are hurting this industry with prosperous future. Those games were so bad with either bad mechanics or poor AI design, and sometimes It caused the company a lot of money, not only because of this one game but also as a result of a damage in this company's credibility. And most importantly, people who play games just to relax and have fun will be hurt. I think that by researching on how to improve AI design to make games more balanced, it can help me to build a recreative means to make people's life better. Since I'm also thinking of going to graduate school to learn CS, this research might be a really beneficial experience for me.

Student Qualifications (200 word limit)

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Include courses and other experiences that have prepared you to carry out the proposed research.

In CS2 we developed a space-shooting game "Galaga" and had a basic understanding about designing a game.

In Functional language I developed my first AI game "Connect 4", where each time the AI was trying to find its best move based on its recursively explore of all the possible outcomes with a cut-off depth.

As a sophomore I already took CS courses like Algorithms, computer Design and discrete structure. I got basically a 4.0 in CS courses. I believe those courses made me more logical and thoughtful in exploring and solving problems.

I took the Game Theory from Economics, which is a Senior-level course that provides me with useful tools when analyzing the relationship between users and AI. During my free time, I wrote my own chess game in c++ with a GUI interface and use RPG makers to make simple role playing mini games. I'm also a die-hard video games fan that know about various games either with good or unsatisfying game design. The experience

I have and the understanding of games accompanied with my skill set and help from Dr.Jiang, I believe, could lead to the potential success of this research topic.

Student Transcript

Attach an unofficial transcript. To do this, visit Tigerpaws. Click on Student Transcript. Print the page to PDF. Do NOT cut and paste the transcript into this document. This alters the formatting and makes it hard to find the information the committee needs.

Transcript

0809639 Shiyu Liu

Course/Section and Title	Grade	Credits	CEUs	Repeat	Term
BAT-1101 6 Spreadsheet Modeling					SP2018
CSCI-2094 1 Computer Science Colloquium					SP2018
CSCI-2195 1 Competitive Programming					SP2018
CSCI-2321 2 Principles of Computer Design					SP2018
CSCI-3322 1 Principles of Algorithms					SP2018
ECON-4370 1 Econometrics					SP2018
ENTR-2111 1 Intro to Entrepreneurship I					SP2018
HIST-1332 2 Medieval Europe					SP2018
MATH-3323 1 Linear Algebra					SP2018
CSCI-2320 1 Principles of Data Abstraction	A	3.00			FL2017
CSCI-2322 2 Prin of Functional Languages	A-	3.00			FL2017
ECON-3326 1 Intermediate Macroeconomics	A	3.00			FL2017
ECON-4365 1 Game Theory	A-	3.00			FL2017
MATH-1320 2 Statistical Methods	A	3.00			FL2017
MKTG-2301 2 Principles of Marketing	A	3.00			FL2017
BAT-1101 5 Spreadsheet Modeling	W	0.00			SP2017
CSCI-1120 1 Low-Level Computing	A	1.00			SP2017
CSCI-1321 1 Principles Computer Science II	A	3.00			SP2017
CSCI-1323 2 Discrete Structures	A	3.00			SP2017
ECON-1312 6 Principles of Macroeconomics	A-	3.00			SP2017
ECON-3323 1 The Economics of Government	A-	3.00			SP2017
ECON-3325 2 Intermediate Microeconomics	A	3.00			SP2017
PHED-1141 1 Basketball	A	1.00			SP2017
MATH-1311 Calculus I	CR	3.00			
MATH-1312 Calculus II	CR	3.00			
CSCI-1320 5 Principles Computer Science I	A	3.00			FL2016
ECON-1311 5 Principles of Microeconomics	A-	3.00			FL2016
FYE-1600 10 First-Year Experience	B+	6.00			FL2016
INTL-1100 2 Interntl Student Orientation	PP	1.00			FL2016
PSYC-1300 3 Principles of Psychology	B	3.00			FL2016

Total Earned Credits 57.00
Total Grade Points 188.00
Cumulative GPA 3.760

OK

Faculty Component

Project Title: Using Artificial Intelligence and Game Theory to Improve Balance in Game Design
Faculty name: Albert Xin Jiang
Student name: Shiyu Liu

Project Abstract (150 word limit)

We study the problem of balance in the design of computer games. This issue is most apparent in multi-player games like StarCraft, League of Legends and Street Fighter, but also in single-player games as well: if a playable character, or other selectable feature of the game (such as weapons or spells) is too over-powered or under-powered compared to their alternatives, users will be incentivized to choose (or avoid) these features. As a result, certain design features of the game will be underutilized and therefore efforts wasted, and furthermore gameplay will become less diverse than intended, which can cause degraded user experience.

We address this problem by formulating a game-theoretic model of how design decisions influence the behavior of users. The model can be built from data using machine learning techniques, and using the model we can make predictions about user behavior, with the aim of helping the game designers making decisions about balance.

Project Significance (250 word limit)

Computer games is a billion-dollar industry. Games like League of Legends and Overwatch have both a large online player base as well as dedicated e-sport professional leagues. Issues of game balance is a regularly discussed topic by players of the games on online forums (e.g. https://www.reddit.com/r/leagueoflegends/), and Riot (creator of League of Legends) has a dedicated "balance team" in charge of continuously tweaking the game's features in order to improve balance. Furthermore, games like League of Legends and Overwatch are continuously in development with new characters introduced regularly. The issues of balance are important when designing these new features; game developers would want the users to be incentivized to play these new characters, but at the same time do not want to destroy the game's existing balance.

Although there have been popular articles written about game balance, there was relatively few works from the AI research community on this topic. Existing approaches seem to be either based on pure data analysis or very simplistic game theory models. In this project we will bring the current advances in game theory and AI to this problem with practical importance, and hopefully generate more interest from other researchers to further study this problem.

Project Outcomes (150 word limit)

Our ultimate goal is to provide a general methodology for modeling and analysis of game design issues, that would be a useful tool to all game designers. For this summer project, we would like to start by focusing on a concrete existing game, and to study its balance issue. One candidate would be League of Legends, a popular game in the Multiplayer Online Battle Arena (MOBA) genre. Statistics and data of games played by the users are publicly available from the game's developer Riot (https://developer.riotgames.com/). Utilizing these data,

we plan to build a game theoretic model, and use it to make predictions about how changes in game features would affect player behavior. Since Riot does make regular changes to try to balance the game and publish these changes in patch notes (e.g. https://na.leagueoflegends.com/en/news/game-updates/patch/patch-82-notes), we can test the accuracy of our predictive model by comparing our predictions to what actually happened following the changes.

We hope to submit our work to a top conference in AI, such as IJCAI, AAAI or AAMAS. We also plan to make our findings available to Riot and other game developers, which I believe they will be interested in.

Method and tasks to be completed during summer (200 word limit)

League of Legends (LOL) is a game between two teams, each with five players. Each player controls a champion, which they pick from a pool of available champions. Each player in a team usually fit into a specific role (Top, Mid, Jungle, Marksman and Support). One issue we would like to study is regarding champion selection: which champions (or combination of champions) are overpowered compared to others? We will start by modeling the champion select aspect of LOL as a two-player game; each player picks five champions from the pool. We then need a utility function that provides the outcome of the game given players' choices, and we can build this function from publicly available data on game histories (https://developer.riotgames.com/) using machine learning. In particular we will explore regression techniques including linear and Gaussian process regression. To model the game's tunable features' influence on the game, we include these features as variables in the regression as well.

Given the game theory model, we will try to answer questions like: what is the optimal strategy in champion selection? Do certain champions dominate others? Or do we have a rock-paper-scissors like situation where no champion dominates? To this end, we will compute solutions of the games using linear programming, utilizing techniques from my recent research. Then we can make predictions such as, if certain features of the game are changed (e.g. the range of a certain attack is increased, or the strength or duration of a spell is modified), what will change in the players' behavior in the modified game.

Budget and Justification(Not to exceed $6000)

Student Stipend $4000
Faculty Stipend $1000
Conference Registration and Travel $1000

Total: $6000

Relation of the project to faculty research agenda (150 word limit)

The project is closely aligned to my research agenda of using AI and computational game theory techniques to solve real-world problems.

While a significant part of my previous research focused on applying game theory to security, this application to game design would further enrich my research portfolio. Applying game theory to the study of balance questions in game design is something I have always been interested in doing; now with an interested and

motivated student, this summer project would be a great opportunity to start.

Statement about student preparation and qualifications (150 word limit)

Shiyu is very well prepared for this project. Although just a sophomore, he has taken / are taking a significant number of Math, Econ and Computer Science courses that are relevant to this project, including game theory from the Economics department, Calculus, Statistics and Linear Algebra, and the core computer science courses like Data Abstraction and Algorithms. These should give him a good mathematical foundation for theoretical modeling of the problem, as well as sufficient computer programming experience to implement solution ideas. I believe this is the perfect time for him to start exploring his research interests by doing a summer project, which would prepare him well for continued research in his junior and senior year.

Shiyu has taken one course (Data Abstraction) from me before; he achieved an A grade and was among the top students in my class. He achieved excellent grades in his other classes as well, many of which are upper-level classes. More importantly, he has shown that he's passionate about learning, and highly motivated in exploring his interests in game design. I believe this project would be an excellent match to his interests, and will be both intellectually challenging and has real-world impact.

Student Reference Letter

(Only **one** is required from a faculty member who is NOT the mentor.
Please send in separate email to psunderm@trinity.edu)

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