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April 15, 2023

Capstone: Price Prediction

Western Governors University

James Laurie

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Part A: Project Proposal for Business Executives

Letter of Transmittal

April 15, 2023

Steve Adams, CTO

Fast Iron

123 Fast Iron Blvd

Hollywood, California

Dear Mr. Adams,

Our organization has long taken pride in being at the cutting edge of the heavy equipment Auctions industry.

However, as technology advances, we find ourselves missing in an area that I believe is vital to the company's future success. Many of our clients have inquired about setting acceptable expectations for auction day sale prices. We are currently not equipped to serve these customers properly. Our company's current focus is on business logistics. We currently lack the resources to capitalize on this innovative method of satisfying our clientele.

With a new data product, I believe we can deliver this service to our customers. This tool will offer our staff the knowledge they need to provide accurate projections to our clients in order to create suitable expectations. It will be a command line interface with all of the necessary information and tools. The program will plot the pricing history for each state, and a bar graph will display the volume of sales for each state. It will also include a Linear Regression technique to forecast future sale prices using sale price data.

This product will help the client in a variety of ways. It will allow the customer to obtain the most accurate information from us in order to assess whether he or she should adjust their expectations on the sale price or the place where they wanted to auction their equipment.

This could result in higher returns for our consumers and improved customer satisfaction. The product's objectives ensure this. The product's goals are to ensure that software users have up-to-date and accurate data on auction selling pricing.

The financing needed to create and sustain the project has an initial cost of \$14,200.

The software must then be maintained for an extra \$2,400 per year. The developer assigned to this task has three years of expertise developing data applications that use machine learning methods. The programmer also holds a Bachelor of Science in Computer Science. I believe the developer will be able to complete this data product on schedule and within budget.

Thank you for reading through my proposal. I'm looking forward to hearing from you.

Sincerely,

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James Laurie

Project Recommendation

Problem Summary

For many years, Fast Iron has assisted its clients in selling heavy equipment at auction. With the unexpected advent of machine learning, many of our clients have inquired about the expected auction price for their equipment. Fast Iron currently lacks the decision-making tools needed to aid our clients in setting acceptable expectations on auction day. Our primary solutions in the heavy equipment area are currently focused on logistics and transportation. Many of our clients are dissatisfied since their expectations were not reached. This is something we are actively working on.

Application Benefits

With a new data product, I feel we can broaden our company's offers. This data package will allow for the examination of historical auction sale prices. Our personnel will be able to successfully recommend the best price our client should expect thanks to the selling price analysis product. They will be able to make more informed judgments, resulting in improved satisfaction ratings.

This tool will display an auction sale price, indicating what to expect on auction day. We can provide advice to consumers who want to create acceptable expectations based on these forecasts. I believe that this product will help our organization improve customer satisfaction. This will also provide us with a competitive advantage over competitors who do not provide accurate expected sale prices.

Application Description

The data product will be a standalone application created in Python, a free and open source programming language. It will require the most recent heavy equipment data from the company database. The command line interface will contain all visual data in one location. A bar graph will show how frequently sales occur in each state.

The price change by state will be shown as a bar graph. There will be a part that indicates the model's accuracy or evaluation. This section's data will be derived through training a machine learning algorithm on prior prices. Linear Regression will be used to visualize future data points based on pricing history.

Data Description

The data used to construct this product will be from the company data warehouse. This data includes heavy equipment data such as:

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SalesID (integer): the unique identifier of the sale

MachineID (integer): the unique identifier of a machine.

saleprice (integer): what the machine sold for at auction

saledate (datetime): the date of the sale

The product will need to be updated weekly with new data, which will then be stored in a cloud database. The data is limited because it is contained in a single file. The product will not have access to up-to-the-minute or second-by-second price changes. As a result, attempting to obtain the price of many pieces of equipment at the same time is outside the scope of this project.

Objectives and Hypothesis

This product serves numerous purposes. One of the primary goals is to ensure that the software's user has the most up-to-date and correct data on heavy equipment auction selling pricing. Another key goal is to process and then show the raw data in order to make it useful. This will assist us achieve our other key goal, which is to increase our staff's decision-making abilities using the processed data. All of this contributes to our company's ultimate goal of offering the best customer service while also giving our clients the best return on their investment.

My idea is that semi-accurate price forecasts can be produced using Regression. This future price information will help our organization make better selections for our clients. I believe that if this product is constructed and maintained, both our company's revenue and client satisfaction will skyrocket.

Methodology

The Waterfall Methodology will be used for this project. This methodology was chosen since the project's needs are well specified. Because the product's feature set is not extremely complicated, a straightforward and linear process will be most effective. This will keep development on track and allow the completed software to be delivered on time and within budget. The following sections of the project correspond to the phases of this methodology:

1. Needs - During this phase, we will meet with the proposed product's end customers to acquire all of the needs.
2. Design - Following that, a design will be built to verify that all of the requirements from the previous phase are met.
3. Implementation - The code will be written during this phase to ensure that it meets both the requirements and the design.
4. Verification - Once the code is complete, a working version will be distributed to end customers to check the product performs as expected.

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5. Upkeep - As end consumers utilize the product, any bugs, insufficient functionality, or other faults will be rectified as needed.

Funding Requirements

The vast majority of the product is built with free and open source software and technologies. However, charges will occur from a variety of sources. One software developer will make up the software development team. The project's projected time frame is 110 hours. A developer's pay will be \$11,000 at \$100 per hour. The developer's first costs for procuring the necessary equipment are projected to be \$3,000. In addition, maintenance costs will be around \$100/hour for 24 hours each year. So, to get a working product, this product will cost a total of \$14,200 up front, plus an additional \$2,400 per year.

Data Precautions

Each state auction facility makes the data utilized in the product publicly available to the public. As a result, there is no sensitive or protected data. The program does not collect or utilize any of the users' personal information.

The product complies fully with conventional privacy rules. When an application works with sensitive data, such as in health care, education, or payment processing, there is both an ethical and legal obligation to protect that data. Many safeguards must be put in place to ensure that the data remains private and does not leak. We don't need to take such safeguards because our product does not use such data.

Developer's Expertise

The developer chosen to create this new product has extensive experience creating and maintaining software. The programmer has three years of expertise creating data applications that use machine learning algorithms. In addition to his or her experience, the developer possesses a Bachelor of Science in Computer Science. I believe this developer is a good option for developing our new data product because of his experience and track record.

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Part B: Project Proposal

Problem Statement

A new type of technology has arisen during the last few years. This new style of data analysis has swept the globe. Machine learning is a technology that allows programmers to use data to forecast sale prices based on specific parameters. This has resulted in clients being led in the right direction in terms of setting appropriate expectations for the sale price on auction day. As a heavy equipment auction company, it is our responsibility to ensure that we have the necessary instruments to steer our clients away from disappointment.

We are currently unable to provide this service to our customers. We need a mechanism to collect more data and convert it into usable information. This data will provide our personnel with the information and knowledge they need to provide the best possible service to our clients.

Customer Summary

The "customers" who will be most impacted by this new data offering will actually be two distinct groups. The first are our staff, who will be using this new data product. These are the people that will be utilizing the product on a daily basis. They collaborate with our clients to determine an appropriate estimated sale price on auction day. The data product will be installed with the employee's other data tools on the employee's machine. The data product will deliver information that is similar to what the employee has previously worked with. A bar graph that displays price history per state, a bar graph that charts volume data per state, and a price forecast section created from a machine learning algorithm are some examples. As a result, our staff will already have the skill sets required to use this new product to its full potential.

The actual customers, our clients, are the second "customers" of this new data product. This group consists of folks who come into our office looking for assistance in selling their heavy equipment at auction. This includes construction organizations, governments, and ordinary people wishing to auction off their heavy equipment. Many of these clients have inquired as to how much they should anticipate to sell their home for. We will be able to meet these customers' needs thanks to our new data product.

Existing System Analysis

Our technologies and solutions are currently geared toward the transportation and logistics of auctioning off big equipment. These tools collect and show data that is specific to particular locations. They do not provide any price prediction information.

This new data product is intended to complement the existing system. It will be installed on the same PCs that are already running our present software. This will enable us to provide accurate projections while continuing to support our current offers.

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The present physical systems will not need to be significantly updated to accommodate the new product. Our employees' existing machines will be able to run the program because they are already capable of running similar programs. I recommend that each system's RAM be upgraded somewhat to accommodate the additional concurrently running processes. I would also urge that each workstation have two monitors. This gives the employee additional screen space to present all of the information necessary to complete their tasks. All of these suggested improvements have been factored into the funding requirements.

Data

The data source will be extracted from the company's data server, where all the information on previous equipment that has been sold at auction has been stored. The data will be collected via a scheduled python program set to run once a week. This program will download data from the company data server and format it in a way that can be fed to our machine learning model. The positive outcomes of this data collection method is that it is time efficient. By writing a small program once, the data collection and cleaning process will be automated.

This method is limited in its capacity to verify the data. If the data stored on the company data server is not accurate for example, then our collection method will not spot obvious errors. We will use the python library pandas to do data exploration and gain an understanding of the data by delving deeply into the variables contained in the data. To correctly expose underlying formatting issues, outliers or dirty data. We will construct a number of visuals and apply aggregation techniques. Data will be removed, corrected, or imputed at this stage. Missing data will be replaced with the value from the previous row of that column, while outliers and duplicates will be removed.

Project Methodology

The Waterfall Model is the industry standard approach that will be followed for this project. This is an excellent alternative for this type of project because the needs will be thoroughly understood in advance. Because only one developer will be working on this project, the linear sequential flow will make it easy for the developer to lead and assist the product's design and development. Each step will generate a deliverable that will be used as input for the next phase. The following describes how each phase will manage the features of this project:

1. Requirement Analysis -
 - a. A meeting will be held with the end users to explore what the software will need to accomplish to effectively support decision-making.
 - b. These needs will be documented for use in the following phase.
 - c. The program's scope will be determined to guarantee that no extraneous elements are included in the final design.
2. System Design -
 - a. During this phase, the documents created in the previous phase will be evaluated.
 - b. The requirements will be examined to verify that the developer understands what the product must accomplish.
 - c. Based on these requirements, a system design will be created. This design will describe the program's structure and how modules will interact with one another.

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3. Implementation -
 - a. The previous phase's system design will be used to start creating the code base.
 - b. Each module's code will be written and tested separately.
 - c. Unit testing will take place at this phase to confirm that each piece of software functions as intended before integrating it with the rest of the code.
4. Integration and Testing -
 - a. Once the separate modules have been written and tested, they will be integrated one at a time.
 - b. After each module is introduced to the code base, Integration Testing will be performed to ensure that each module interacts properly with the others.
 - c. System testing will be done once all modules have been integrated. The entire system will be tested to guarantee that there are no flaws or problems.
5. Deployment -
 - a. After testing is completed and any detected defects are rectified, the product will be released to our employees' computers.
 - b. Acceptance testing is performed at this step to check that the program functions as intended.
 - c. The program will be installed alongside the currently available financial data tools.
 - d. Any hardware changes required to enable the inclusion of new software will be completed during this time.
6. Maintenance -
 - a. Issues are bound to develop after the software is released and in use on a daily basis.
 - b. This step is ongoing throughout the life of the software because there is no such thing as a bug-free program.
 - c. Patches are released during this phase as issues arise and are resolved.

Project Outcomes

The finished application will be sent to the customer once the project is completed. The program will feature a command line interface, as well as access to user and administrative interfaces and maintenance functionality. The user guide will be given for documentation reasons, explaining the user interface and offering installation instructions. Finally, the project schedule will be supplied, together with planned and actual milestone completion dates. A scope statement will also be produced to ensure that all parties understand what features will be implemented and what ones, such as numerous price projections at once, are outside the scope of the project. The next phases will generate documentation related to the program's design. One of these documents includes a flowchart that describes the code's structure and how the modules will interact.

To get a sense of how things will look, a command line interface will be created. A testing strategy will be developed here to guarantee that the next phase is ready to begin creating code. The phases that follow will generate deliverables linked with the second category, Product Deliverables. The source code modules for the program will be built during the Implementation phase, and the finished program will be the result of the Integration and Testing phases. We will then have a fully functional command line

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interface. Following those processes, a database file containing up-to-date heavy equipment data will be created.

Implementation Plan

It will be time to put the product into production once it has been manufactured. The strategy

It is explained in full below:

- Implementation strategy - Ensuring successful integration with existing systems and workflows is a vital step for every software development. The program will be built from the ground up to operate with existing software and systems. This ensures that when the new data product is ready for use, it may be readily installed onto existing computers without interfering with the old programs. Another important consideration when implementing new software is ensuring that the new software interfaces properly with existing workflows. Because the data product is meant to function similarly to our employees' present tools, the transfer will be lot easier for our staff once the program is released.
- Roll out Phases - First, the product will be placed on a modest number of our employees' computers, such as three or four. They will conduct acceptance testing to confirm that the program meets all of its original specifications. The product will then be installed on a small set of employees' computers (between 10 and 15). These staff will work with a small number of clients to get them to use the program and start investing in Bitcoin. Any issues that are discovered will be resolved within a few weeks. Finally, the product will be distributed to all remaining personnel, and production will begin.
- Testing levels and final distribution - Testing will be performed at each stage of the roll out. Acceptance testing will be performed during the initial stage to confirm that the original requirements are fully met. The subsequent stage will put the program through its paces in a controlled production environment. A few clients will begin to collaborate with our workers and the program in order to start using the product in a live context. Any bugs detected will be fixed and fixes issued at each of these processes. Once all concerns have been rectified, the final roll out will take place, and the product will be provided to all of our staff.
- Milestones - Each stage of the product's release will be marked with a milestone. Each milestone will bring the product closer to completion. These milestones will be developed and scheduled in order to keep the project on track and the final distribution release date from being pushed back.
- Deliverables - Several documents will be created during the implementation. During the rollout's acceptance testing, a document explaining and finally accepting the product will be prepared. This will ensure that the product fits the original specifications. During the testing phases of the roll out, bug reports will be generated. The CTO will sign off on a project closing document, proclaiming the project complete and concluded.
- User testing - As previously stated, user testing will take place at each stage of the roll out. Any bugs found will be documented in a bug report. These will be addressed later, and fixes to the program will be released.

Evaluation Plan

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Verifying and verifying that the application meets all of the requirements is an important step in any project.

Testing will be essential in ensuring that the application accomplishes what it is designed to do. At each stage of the development life cycle, tests will be performed. Following the completion of each module of code, unit testing will be performed. Before writing the next module, each module must pass its own tests. Each time a module is introduced to the code base, integration testing will take place. This will ensure that the modules interact effectively with one another. After the product has been entirely written, system testing will begin to confirm that the program as a whole is functioning properly. Finally, a selection of end users will undertake acceptance testing to ensure that the product meets all of the requirements that were initially outlined.

Outside of the standard testing, further verification and validation will take place. Once the product is fully deployed, we must guarantee that it achieves its primary goal of satisfying our customers. This will be accomplished by regularly monitoring the performance of our customer's surveys, which were distributed to each client following an auction. We will consider our product successful if at least 60% of these clients enhance their level of satisfaction during the first year of its release. This will be a metric used to determine whether the product was effective in meeting its primary goal.

Resources and Costs

Costs are an important consideration in any undertaking. Fortunately, our project mainly relies on free and open source software and technologies. Furthermore, the majority of the hardware requirements are already in place within our company.

The following is a breakdown of the project's costs:

- Programming Environment - Hiring a developer isn't the only cost associated with this project. We must ensure that the developer has the necessary tools. In terms of gear, we must equip the developer with a laptop to work on. The developer's work laptop will be purchased with a budget of \$1,200. The majority of the software required to execute the project will be available for free. Python, Pandas, Sklearn, the Python Integrated Developer Environment, and third-party Python libraries are all open source and free. If the laptop does not arrive with Windows preloaded, a Windows 10 license must be acquired.
- Costs related with the environment - Because the developer will be sharing office space with our other employees, the costs generally associated with renting office space will be shared by the already existing staff. As a result, these expenses will be negligible. A central server to house the database will be purchased for \$2,000. Electricity and internet bills will also be distributed among existing staff, resulting in very low prices.
- Human Resource Requirements – The bulk of the costs for the project come from the salaries of the employees. Our project requires only one developer, so we can keep our costs at minimum.

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Timeline and Milestones

The project will take around a month and a half to complete. The completion date is set for May 1, 2023.

Over the duration of the project, approximately 110 hours will be spent fulfilling milestones. The following is a breakdown of the timetable and intended milestones:

Milestone	Start and End Dates	Duration	Resources
Analyze Requirements	March. 23 – March.25	10 hours	Stakeholders and end users
Design of Code Architecture and Flow	April 30 – April 31	10 hours	Programmers
Module Development and Testing	May 15 - May 20	30 hours	Programmers, QA Engineer
Module Integration and Testing	May 25 - May 30	15 hours	Programmers, QA Engineer
Stage 1 Deployment and Acceptance Testing	June 1 - June 10	5 hours	Programmers, End users
Deployment	June 15 - June 30	10 hours	Software Developer, End Users, Stakeholders

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Part C: Application

Application Files:

- colab.ipynb
- TrainAndValid.csv

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Part D: Post-implementation Report

A Business (or Organization) Vision

We had no way of providing realistic price forecasts to our clients prior to the completion of this product. We lacked the necessary data and information to estimate how much a piece of equipment would sell for at auction. This put us at a disadvantage in comparison to other companies who used these services. It also left several of our previous auction consumers dissatisfied because their expectations were not met.

The application that was created was able to fulfill our clients' worries and expectations. Our staff were now provided with a pricing prediction tool, which enabled them to obtain the information they required to create suitable expectations for our clients. This is advantageous to the client because they can now set appropriate expectations at auction by inputting the equipment information and receive a predicted price to be sold. The completed application met all of the requirements of the software's end users. They required a method for predicting the auction sale price of a certain piece of heavy machinery. This was accomplished by developing an accurate supervised machine learning model to forecast the auction sale price of a certain piece of heavy machinery based on its intended usage, equipment type, and configuration.

Datasets

The program uses raw data pulled from our database and saves it to a csv file. The processed data is a cleaned version of the raw data that replaces the null values with the value from the previous row and any values that were unable to be filled were dropped. Then the datetime column was converted to a datetime data type and split into individual columns.

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SalesID	# SalePrice	MachineID	ModelID	# datasource	auctioneer...	# YearMade
1139379	18500	70214	13395	121	3	2004
1139382	10000	1068548	112	121	3	1000
1139390	8250	1011114	7110	121	3	1000
1139398	20500	138847	7043	121	3	2001
1139401	9500	1011478	18604	121	3	2003
1139409	51000	999090	3362	121	3	1000
1139412	39000	108090	1088	121	3	2006
1139413	58000	1045512	5853	121	3	2001
1139415	15500	1066239	17188	121	3	1996
1139418	7750	1026462	6270	121	3	2001
1139421	32000	1048704	2797	121	3	2000
1139423	11500	999442	3217	121	3	2003
1139424	12000	1011821	4818	121	3	1000
1139426	75000	625882	23937	121	3	1996
1139429	5500	1007166	7002	121	3	2001
1139432	28500	362075	1078	121	3	2003
1139445	35500	1066661	13776	121	3	1998
1139449	11500	115392	7014	121	3	2002
1139450	35500	1059046	1830	121	3	2003
1139451	30000	980151	13776	121	3	1998

Data Product Code

The data was analyzed in multiple ways. My descriptive method was to use charts and graphs to visualize the data. By doing so we were able to see the decrease in the number of null values as well as the frequency of sales and price changes by state. This was useful to make sure our data is prepared properly to train our model as null values will cause an error.

My predictive method was where I created and trained the regression model. Regression analysis is appropriate for the project because it is used to describe the relationships between a set of independent variables and the dependent variable. Regression analysis generates a regression equation in which the coefficients represent the connection between each independent variable and the dependent variable. With this we were able to untangle complex issues with entangled variables to obtain a semi-accurate price prediction model.

Objective (or Hypothesis) Verification

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The design of this program was guided by the notion that combining an organization's heavy machinery information such as intended use, equipment type, and configuration and passing through a supervised regression model would result in an accurate pricing estimate. The hypothesis could not be confirmed with the test dataset. However, due to a lack of processing resources, the theory cannot yet be disproved. Gains in any aspect of computer power and algorithm optimization, could result in large gains in prediction performance.

Effective Visualization and Reporting

To analyze the data I first looked at the table to get an understanding of what information is present or missing and their data types. I also looked into statistical descriptions of the numerical columns as well as the size and shape of the data. This is useful in supporting our model by checking that the data is relevant and exists. Without this check the model can not be trained.

To explore the data I used bar charts to visualize the data. Before doing any cleaning I created the first visualization of the number of missing rows or nulls for each column. Then after attempting to fill the null values with the value from the previous row, the second bar graph was created to visualize the difference and show that values were indeed filled. For a third visualization I created a bar graph of a count of each value for each state, giving us a frequency by state graph or the states with the most auctions. This is useful to find any outliers in the data as I was able to identify three states that contain the majority of auctions.

Accuracy Analysis

Scikit-Learn has functions for determining how effectively observed outcomes are replicated by the model. These are the functions `r2_score()` and `mean_absolute_error()`. `r2_score` is a regression score function with a coefficient of determination that can be used to give us an accuracy percentage. While mean absolute error (MAE) is a measure of differences between paired observations that will show on average how far off each prediction was. After determining the training and testing datasets, the model fits the training data and executes the scoring function on the test data.

Application Testing

Using a top-down development process enabled each module's functionality to be tested as part of the integrated whole throughout its coding. As a result, the input and output of each module were examined at the database level to guarantee that the intended outcomes were obtained. Each module change necessitated resetting the demonstration database and re-running the program. This proved to be more time consuming than adding unit testing. The resulting modular software has been confirmed to perform as planned, with each module accepting and producing the correct inputs and outputs.

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Application Files

The Python programming language makes it very simple to construct attractive, CLI-based programs with a small amount of files. The source code is contained in a single '.ipynb' file. This file is called colab.ipynb. The database file is another file that the application makes use of. This file is called TrainAndValid.csv. If this file is not present when the program starts, it will crash.

/Google_colab

colab.ipynb

drive

MyDrive

TrainAndValid.csv

User Guide

Prerequisites:

- Google Account

The following details the steps required to install and use the application:

1. Download the ipynb and csv files from the provided zip.
2. Log-in to <https://drive.google.com/>
3. Click new in the top left corner of the screen.
4. Click on File upload.
5. Upload the TrainAndValid.csv and colab.ipynb files
6. Double click the colab.ipynb file to open the program.
7. Proceed to run the code allowing access to your google drive.
8. Choose what model to evaluate at the end.

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Summation of Learning Experience

The Computer Science curriculum at Western Governors University, on the other hand, has been the most important factor in my achievement. This degree program provided me with a good foundation in computer programming. Many previous experiences aided me in the accomplishment of this job. My existing knowledge of Python programming came in handy during this endeavor. I was able to write working Python code using the abilities I learnt on my own. I had taken free online classes in Python that taught me how to create graphical user interfaces, graphs using seaborn, and data analysis applications. These abilities were necessary to create the data product required for this capstone.

This project had one requirement that needed me to seek assistance. When I began this project, I knew very little about machine learning techniques. However, I was able to locate a video series on Linear Regression created by a highly talented and capable coder. I learned a lot about Linear Regression and how to use it from his courses. I used what I learnt from him to create my machine learning system for predicting future auction prices. This event taught me that no matter how much knowledge you gain in the future, there will always be something you don't know. Learning is an ongoing process. I will now be more willing to seek assistance and expertise from others. This study demonstrated that technology is a fast-paced environment in which we computer engineers must always seek new knowledge and assist in keeping up with these changes.

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