Group Project - Description

The past ten years have seen a significant increase and growing trend in adopting electric vehicles, which store the energy needed to operate them in large batteries. A fully-charged single battery will typically result in 250-300 miles maximum driving distance before a recharge is required. When traveling primarily locally, scheduling when to recharge the vehicle is relatively easy as you can find stations scattered throughout many North American cities, as well as at your place of residence. However, when traveling distances greater than 250-300 miles it is necessary to stop and recharge the battery. In this project you will focus on the specific context of long-distance travel.

Some companies such as Chargepoint and Tesla have already identified the need for more charging stations. However, the current road infrastructure remains largely focused on gas-based fuel. Suppose that you are in the not so distant future where most cars are electric. The purpose of this project is to determine the number and best placement of charging stations over very large geographic regions, with the goal of maximizing revenue over a 5 year span and ensuring that your solution is within a given budget. How to accomplish this goal is the business opportunity that your group must meaningfully address.

An electric car charging station could consist of multiple chargers. There are the standard level 2 chargers and the DC fast chargers to choose from. It takes 10 hours to fully charge using a level 2 charger and 2 hours if using the DC fast charger. You can assume that the cost to install a level 2 charger is $5000 and a fast charger is $50000, respectively. There are also many business opportunities for partnerships at charging stations. For instance, you could collaborate with a convenience store or a hotel and get a revenue share (10% with a convenience store, 20% with a hotel). A hotel has 1 charger for every 5 rooms and can generate an average profit of $60 per room. A convenience store can generate an average profit of $10 per customer, and has 5 chargers. Note, the operating cost of a hotel is important and you can assume this is $10,000 per room per year, and for a convenience store is $12,000 per month. You must ensure that your partners are able to turn a profit each year!

To help solve the overall problem you should consider your predictions of operating electric cars, and different potential behavior patterns of passing through customers (for example, if it is a tourist area then maybe there is a high demand of overnight customers, or if many customers may arrive around meal times you can pre-order meals to eat while the vehicle is charging. Most customer wont spend as long as 2 hours in a convenience store, but could spend as long as 10 hours in a hotel.). The rate to charge each car is $1.00 per hour or $7.50 per session if it is a fast charging station.

The project has the following main requirements, noting that there are many details to figure out, model, and resolve to accomplish these tasks.

- **Algorithm for placement and design of electric charging stations.** For a given geographic region in the United States your solution will include a number of charging stations, the geographical locations of each electric car charging station, its charger type(s) and number of each, as well as partnership type(s). You will need to provide evidence that you can solve different region sizes and traffic patterns, under different budget constraints, and provide estimate average revenue/costs/etc (simulation of traffic will likely be needed!), while minimizing total charger installation costs. For the traffic to the charging station you may need to create a simulation. The algorithm should be general purpose so that it can be applied to any geographic region with no changes to the code (you will need to define what the input data looks like - it should be reasonable requirements!).

- **Data Analytics.** You will need to use statistics and machine learning to devise descriptive and prediction models that can be used as summary information that is useful for your company to make decisions about the design of the system or the daily operations and economics (e.g., customer traffic at any charging station over different periods of time, per-station revenue, etc.). Use different kinds of appropriate plots to visualize the results. The data analytics should yield a concise pdf report meant for CFO/CEOs that is generated from R. An example could be found at `https://chargehub.com/en/charging-stations-map.html`

- **Web Interface.** Customers (those who drive/use electric cars) should be able to login to your web portal and view existing or historical traffic patterns and trends, wait times and other useful information about the transportation routes and charging stations. Moreover, they should be able to plot a route to a destination and indicate whether they would like a hotel, any choices of food, to just quickly charge and go, etc at each of the charging stations along their path - and for how long they would like to stop at each station for.

There is some data available that you can use when creating your solution (e.g., to estimate the traffic pattern). However, it is expected that your project should be applicable beyond this basic data set. `https://www.kaggle.com/jboysen/us-traffic-2015`

1 Project Guidelines

There is obviously significant freedom in your group vision, and creating a realistic plan for success and carrying it out will be challenging. Along the way there will be many choices, often with nuanced subtleties that need careful group brainstorming, analysis and some research. You will also need to make numerous assumptions, but be very careful that they are realistic or have insignificant impact on the final product. In order to accomplish the project goals you may need to devise and experiment with various machine learning tools, simulation models, databases, analyses in Javascript/PHP/R, etc. Be very careful and thorough in your approach so as to make efficient and effective use of your time.

These project guidelines indicate the **minimum** requirements. Exceeding minimum requirements will be considered for bonus points. Each group has a significant degree of creative freedom in implementing these goals but cannot violate any constraints/requirements. You are highly encouraged to utilize previous experiences in addition to the technologies discussed throughout this course in order to devise the best possible solution, but check with the Professor if these will have a significant impact on the project. In the event of uncertainties or unknown information you must provide reasonable assumptions, backed by clearly articulated and sufficient evidence (e.g., references, statistics, logical deduction, etc.). The technical aspects of project will be composed of three phases, as described below. At each phase further information, data and hints may be provided. The phases are meant to ensure the project is progressing adequately, and it is expected that the final project will have differences from each phase. Phase 1 and 2 reports are independent, but Phase 3 report is all-encompassing and in a style that focuses on results versus implementation details.

Your grade will be determined based on the two summary reports, final project report, group presentation, individual assessments, as well as sophistication and correctness of your solution. Sophistication does not imply complexity, but rather an intelligent choice of appropriate methods, sound logic and analysis that provides an efficient solution that is presented in an easily interpretable fashion. Including ill-functioning code or inappropriate solutions will result in further loss of grade.

Phase 1. Preliminary vision and group dynamics

As indicated above, there are a number of aspects to this project and it is critical that each team member have a solid appreciation for the nuances hidden in each. Moreover, it is also critical that individual and group expectations are clearly articulated, and means for conflict resolution are discussed. These form the two main subjects of Phase 1. **Do not underestimate the importance of this phase.**

To show that your group has thoroughly thought of the problem you will need to provide a brief but detailed outline to accomplish each of the aforementioned facets at the end of the project description. Diagrams are highly suggested, and at minimum you should have CLEAR web interface designs for each user interface (no HTML/code is expected, only sketches). A website map, that shows the flow of pages each user could progress through is also required. Part of the problem is concerned with a budget optimization problem and your group should have some very clear strategies as to what you want to minimize/maximize and any constraints on the system. Provide this model in your report, use math as appropriate - no code is expected at this point. Finally, a summary concerning the initial ideas for the what kinds of patterns and visualizations you think will be relevant to try and find should be included.

In addition to the above tasks, provide brief but complete replies to the following questions:

1. What expectations do you have for each other and the group? (i.e., meeting frequency, being on-time and sticking to schedules, timely reply to emails, strive for 100% or 80% final grade, report writing process and proof reading, specific coding standards and organization, etc.)

2. How will you go about making important design, coding or other strategic decisions?

3. How will your group handle conflict resolution? (i.e., if one or more team members are not contributing sufficiently or fail to attend team meetings, firing team members, multiple plausible solutions to a specific problem, etc.)

4. What are the strengths and weaknesses of each team member? How will individuals and the group go about turning each individual weakness into a strength? How to monitor this progress?

5. How will you organize the workload and manage responsibilities? (i.e., work on each part equally, collaborate on broad concepts but small teams solve details of a solution, etc.) While it is tempting to leverage the skills of initially stronger programmers as nearly every past group in IE332 has recommended, you should NOT assign a few members to do most of the programming. Everybody needs to be involved in all aspects or historically the project grade will suffer severely (even with 6 members in a group there is a HUGE amount of programming work that cannot be done well by only 3-4 group members).

Submission: A maximum 4 page summary report (NOT including cover pages, table of contents or references) will be **due on Feb 13, 2020 by 11:59pm** (Blackboard submission). Your answers to the above questions are included in the page count - you should not need more than 1.5 pages to answer them.

Phase 2. Database design, optimization and initial analytics

By this stage your group should have completed the database design, implemented it in MySQL and populated it with data. **You are highly encouraged to begin the ER diagram early and to discuss your concept with the course instructor and TAs**. As you have learned more about the system you will develop, any changes to the website design from Phase I should be included in the appendices. It is expected that you will have changes. You should also have made significant progress toward designing and implementing your optimization algorithm - it should essentially be complete and you should already have code running that gives good initial results.

Note: the database design is critical and is typically a time consuming process. Your group is responsible for adhering to proper database design principles as discussed in lecture. DO NOT SUBMIT ANY CODE.

Submission: A maximum 5 page summary report (NOT including cover pages, table of contents or references) of only this phase is due on **March 11th 2020 by 11:59pm**. DO NOT INCLUDE ANYTHING FROM PHASE 1. The database design (ER Diagram) must be included in the report, generated with an appropriate software - it should be clearly visible/not fuzzy. Changes to your website map must be included in an appendix. Also in an appendix will be a chart showing your outstanding tasks, and timeline to complete them - be REALISTIC and given some slack time as well since you will DEFINITELY encounter unforeseen challenges. Remember, absolutely no R, SQL or other programming code should be included.

Phase 3. Final Product

The final phase of the project will complete all outstanding tasks, ensuring full functionality of code, database integration and analytics. **Plan to be busy, there is a lot of work.** Appropriate statistical tests or machine learning approaches must be chosen and adapted in real-time to changes in the database. It is imperative that all plots are proficiently devised, appropriately color-coded/labeled/etc and present information in an intuitive manner. All code must adhere to best practices, and automatically adapt to the addition or removal of new data in the database. Your code must be well documented and tested with appropriate comments, variables names, functions, etc. **The completed project is expected to be of extremely high quality.**

Submission: Upon completing this phase your group will submit a comprehensive final report that will be due on **Apr 29th, 2020 by 11:59pm**. The final report must be no more than 12 pages, not including references, appendices, table of contents and cover page. **Be sure to spend a significant amount of effort writing the report** as it is extremely important, not only to your overall grade, but being able to write quality reports is vital to success in both industry and academia. Further submission details will be provided after Phase II.

2 Report and Presentation Guidelines

Report Format

All reports will be written in 11pt font with 0.75in margin, single-spaced and must include a cover page with all group members names and PUIDs. The cover page is not included in the page limit nor are any references, appendices or the table of contents. Reports MUST be professional and appropriately balance figures/tables/diagrams with clear and consise descriptions of reasoning and analysis in a manner that allows easy reading and discovery of information (e.g., diagrams, tables and lists instead of overly detailed and lengthy paragraphs). **Do not include "filler" text or (oversized) images in your report as it will adversely impact your grade**. Some references and examples for business report writing can be found at the links below, and you are encouraged to seek other examples as well:

- owl.english.purdue.edu/owl/section/4/16/

- www.wikihow.com/Prepare-a-Professional-Report

- www.makeuseof.com/tag/writing-professional-reports-documents/.

Without exception all reports must be in PDF format. A link to hand in reports to Blackboard will be provided. Summary reports are not indented to be final versions, rather they are to help you organize your work over the long duration of the project. Appendices are to be utilized to show supplementary information referenced in the main text (e.g., your final report should NOT show the ER diagram in the main text but instead in the appendix).

1 BONUS mark will be given for creating final reports in `.pdf` using LaTeX(www.latex-tutorial.com), where it is suggested to use the Texmaker www.xm1math.net/texmaker or Overleaf www.overleaf.com editors. You are encouraged to use this approach for all phase reports. All LaTeXsource will be submitted.

Presentation

Each group presentation must be completed within a maximum of 5 minutes. This will be strictly enforced. There will be no question period afterwards or during the presentation, and hence it is extremely important to have a clear and concise presentation. Due to the time limit there are no restrictions on whether a single person or multiple people from your group present, but **ALL** members **MUST** be present and standing with the group. The material presented is chosen by your group, with the intended audience being potential users.

Your slides must be created in a software compatible with Microsoft Power Point or Adobe PDF. On the day of your presentation, the slides **MUST** be brought to class on a USB drive (no downloading from emails, dropbox or other network source will be permitted) and copied to the instructor computer before class begins. No exceptions will be granted - failure to adhere to this will result in a grade of zero on the presentation. Be sure to have multiple copies in case of USB failure (e.g., have at least 2 USB drives, each with a copy of your presentation).

3   Grading

Your grade will be primarily based on proper functionality and design of the overall solution as well as the final report and presentation (a sample grading rubric will be provided). Each phase 1 and 2 summary reports will be given a grade of $\{0, -1, -2\}$, where a 0/0 implies the report was professionally presented (no grammar/spelling errors, easily readable and organized), included all the required information and your solution is appropriately developed for that stage. A -1 indicates the report was lacking in one of professionalism or information content, and a -2 indicates the report was not professional and did not include the required information. **NOTE: this grade is NOT reflective of the correctness of your solution.** The sum of your summary reports will be added to your overall project grade and hence your goal is to get 0/0 on both summary reports. There is absolutely zero tolerance for late reports. As with usual policy, academic misconduct will also have a zero tolerance policy and will be applied to the entire group, without exception.

Along with each project report, each group member will submit a brief scorecard detailing the level of involvement of other group members. This scorecard WILL be taken into consideration when allocating individual grades (either positively or negatively). So, if you decide to abandon your responsibilities then your mark will severely suffer.

You are free to use source code found on the WWW, but be sure to properly reference it in your report. No loss of marks will result by using external source code if it is properly referenced. Improper referencing is academic misconduct, as indicated in the syllabus.

IMPORTANT: Your grade is NOT based on whether minimum functionality was merely achieved, that is an assumption of all groups. Failure to meet minimum requirements will lead to significant grade deductions. Instead, your grade is based on whether your solution is effective and appropriately designed, tested and presented. That is, if your group aim is solely to complete the minimum requirements without providing effective solutions, then your grade is likely to be VERY low. The goal is for each group to provide a solution and report as they would in an industry or government environment.