15-300 Project Proposal: An exploration into the relationship between Optical Illusions and Computer Vision
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1 Project Description

During the spring semester I plan on working with Professor Tai Sing Lee on an independent research study that is exploratory in nature. To provide some context, Professor Lee, is a faculty member across many disciplines including our CSD, MLD and CNBC. As a result, his research focuses mostly on the intersection between neuroscience, and machine learning, specifically the topic of perceptual vision. Although, the proposed research topic does not necessarily build upon past research done by him or his group, it is very much related to this intersection.

At a high level we want to further understand the phenomenon of visual illusions through machine learning techniques. Motivation for this topic begins at some relatively superficial connections between the two. Computer vision has exploded in recent years due to developments within deep learning. Tasks like object recognition can now be done with extremely high accuracy rates, and as a result, these models have been given more societal importance (self driving cars to name one). However, with the advent of its importance, comes an increasing need for these models to see 'correctly'. The inability to correctly recognize a stop sign with a couple stickers as an example is unacceptable. However, we should also note that our vision isn't 100 percent accurate either. This is where optical illusions come to play.

Informally, optical illusions encompass the category of images in which either deceives the viewer, or appears to have multiple interpretations. They are often a topic for psychological studies, and to this day not are completely understood. With respect to computer vision, one could in fact argue that these illusions act as adversarial samples to humans. The ambiguity of optical illusions thus makes it an interesting topic to view from a machine learning perspective. With this motivation in mind, it brings many different challenges and goals to pursue.

To start with challenges, we once again note that this project will indeed be an exploration to a the potential field. As of writing this, little serious literature has been written on the topic. This makes it difficult to judge the direction of a research topic, scope feasibility, and little ability to compare to some state-of-the-art. Potential reasoning for lack of literature could be lack of apparent,immediate applications as compared to other computer vision problems like object recognition. With this in mind, though the proposal has some concrete goals in mind, on challenge will be to solidify a strong research question, that can bear potentially meaningful results within a semester. However, with lack of strong foundation for the topic, this enables us the freedom of experimentation. As a result, we have two main avenues worth looking at.

The first big goal, is to help improve our interpretation using machine learning. There are different views of optical illusions and vision in general within the neuro-science community. By

constructing a potential model that mimics some of these behaviours, we could potentially help strengthen our understanding of the topic. Another plausible problem is the generation of optical illusions through a neural nets. (Interestingly, extremely recently there has been a group who attempted this problem but could not find any meaningful results)

The second goal would be the converse, attempt the use of optical illusions to improve our understanding of machine learning. This would encompass problems like using illusions as adversarial samples to increase robustness of models, or using them to help generate appropriate adversaries to train against.

Overall, the overarching goals are relatively well defined, but work needs to be done in narrowing onto a specific, sizable problem.

1.1 Project URL

The url that will keep track of the project is:

2 Project Goals

Listed below are the 100,75 and 125 percent goals:

100 percent: Sufficient research will be done that satisfyingly contributes to better understanding of one of the two main goals. This will most likely include thorough exploration into one or two problems within the goal. Thoroughness will not be judged based solely on results, since they are not guaranteed, but by heuristics like number of different approaches, consideration and understanding of why no meaningful results were generated. Hopefully, the project will be able to focus the emerging field to lead to future research.

75 percent: Limited research will be done that contributes to one of the two main goals. This will encompass decent exploration of one problem. Compared to the 100 percent goal, an additional month approximately, would make it sufficient to feel around 100 percent.

125 percent: One goal will be sufficiently researched and potentially the second goal can be preliminary explored. This would look like potentially two problems are well explored within a goal, two problems that are related from the different goals are combined, or one problem that is extremely promising is heavily explored. Ultimately, feeling of going above and beyond describes this goal.

3 Milestones

3.1 15-300 Technical Milestone

For the technical milestone, there are a couple tasks that should be achieved. The rest of the semester should be invested into deeper understanding of the psychological aspects of optical illusions, as well as potential models that are to be used. These efforts are ultimately used to pin down the specific problem/s that we want to tackle. By the end of the semester, a specific set of approaches should be settled upon, so that the spring semester involves actual experimentation rather than scoping out the project. ned

3.2 Bi-weekly Milestones

Please note, it is currently somewhat difficult to set out bi-weekly milestones due to potential changes in the near future. Currently, a reasonable approach to milestones will be jotted, and as

the project becomes more and more defined, revisions to the milestones will be done as necessary.

Feb 1: Generation of the dataset will be conducted by scraping images off the web.

Feb 15: Dataset processing is completed, and 1st model is designed and trained

Mar 1: 1st model is sufficiently completed and trained, begin testing and adjust either model or dataset as necessary

Mar 22: If model looks promising, further testing, revisions, training can be done, otherwise wrap up the first method and move onto the second approach.

Apr 5: Second model is designed and trained

Apr 19: Second model is tested, and 75 percent of the project is completed.

May 3: 100 percent of project completed.

4 Literature Search

Currently papers on reproduction of illusory motion have been read that are directly applicable to the project have been read. Otherwise, general papers on optical illusions and machine learning (specifically DNNs related to computer vision) will provide good background for the project. These papers will come through online searching as well as recommendations by Professor Lee. Weekly lab meetings will also be attended in order to gain a better understanding of neuro-science and machine learning's intersection. Any other information will most likely be found through Professor Lee's notes from his perception course, or through machine learning courses from CMU.

5 Resources

The most important resources will most likely be the datasets as well as the neural net API's used. The dataset images will be extracted online, as there is a website dedicated to finding the best visual illusions produced in a single year, which looks promising. Another potential avenue, is that a recent paper reference earlier has a dataset of 6000 images, and so an inquiry into using the dataset may be made. The api's used will most likely be open source.

Finally, as for the hardware, the machine cluster used by the group will most likely be used