Application of Machine Learning for Preventing the Unnecessary Use of Low Energy Doors

Analysis of Solyndra's Failure Through Actor-Network Theory

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On my honor as a University student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments.
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Introduction

Without a doubt, the fight against climate change is and will be one of the most important battles in the 21st century. President Biden created the National Climate Task Force, which created goals to reduce greenhouse gas emissions to about half of the greenhouse gas emissions in 2005 by 2030, transition to carbon-free electricity by 2035, and reach net zero emissions in the economy by 2050 (The United States Government, 2023). To meet these goals, we must find some way to reduce the energy consumption of buildings, especially on temperature maintenance. The Department of Energy estimates that the building sector makes up about 76% of the total electricity usage and about 40% of the total primary energy usage in the United States (Department of Energy , n.d.); heating, ventilation, and air conditioning (HVAC) uses about 38% of the building's energy (González-Torres et al., n.d.).

One way to reduce a building's energy consumption on HVAC is to only allow people with disabilities or carrying heavy objects to use low energy doors, or low energy doors. Allowing able-bodied people to use low energy doors not only consumes unnecessary energy to open the doors but also keeps the door open, allowing air to escape from the building and causing unnecessary energy consumption to bring the building to the desired temperature; Northern Kentucky University spends about $7,000 a week to operate low energy doors, which does not take into account the heating or cooling lost (Coakley, 2013). I propose installing cameras above automatic doors. These cameras will feed images to an embedded device, which would function as a small computer, with a trained machine learning model, to determine whether or not the door should be opened after a person presses the low energy door button. The door will not open for an individual that does not need assistance, which would serve as a deterrent. Not only would this upgrade to low energy doors align the technology closer to its intended purpose, it would also reduce the overall energy consumption by a building's HVAC to help the United States meet goals necessary to combat the climate crisis.

Technological innovation alone cannot combat the sociotechnical challenge of climate change. Technical actors are only a part of a larger network of different types of actors that can interact to strengthen or weaken each other; they can all work together to achieve a goal. To better understand the societal factors and how different actors can interact with each other, I will use the Actor-Network Theory, a STS framework, to analyze both the technical and non-technical actors that played a role in Solyndra's, a solar photovoltaic company, failure to be widespread and its collapse. Understanding solely the technical aspects while ignoring the social aspects would lead to a development of a system that may not suit the needs of the community or maintained by the community, leading to the technology not receiving usage or attention, which defeats the purpose of creating a technology to assist with the National Climate Task Force's 2030 goals to combat climate change. Because of this, we need to account for both technological and societal factors. My technical project proposal will explain how the camera and embedded device can be integrated with the current low energy door as well as the software necessary to facilitate the decision of whether to open or keep the door closed. My STS project proposal will apply the concept of Actor Network Theory. I will inform my technical design by applying insights from my analysis of Solyndra's failure to be widespread to ensure smooth interactions between the technical actors within my technical project as well as the non-technical actors involved in its acceptance and integration into buildings.

Technical Project Proposal

The low energy door provides people with disabilities access to both public and private buildings. Without them, people with disabilities cannot freely enter or exit buildings without the assistance of others. However, the design of the low energy door does not have any mechanism to prevent able-bodied individuals from abusing them: a Stanford study found that 73% of people that use the low energy door button do not have a handicap (Hoffer, 2011), and a student news organization, the Advocate, reported that many of the buttons to open low energy doors on Contra Costa College campus are broken due to mistreatment or out of battery due to overuse (Cheng, 2016). Because of this abuse of low energy doors, able-bodied individuals are able to undermine both efforts to reduce carbon emissions and create an accessible environment for people with disabilities.

Current solutions to deter able-bodied individuals from abusing the low energy door has mainly taken the form of awareness and education. As demonstrated in previous sources, the Stanford and Contra Costa College newsletter have reported their findings to the students of their respective campuses. Recycle Nation, a website with a broader audience that is dedicated to living sustainably, wrote an article that echoed the same sentiment (Stearns, 2015). Although awareness and education is the first step to addressing a problem, the message only leads to action if it resonates with the individual and only spreads if there is a continued effort and interest. Unfortunately, awareness and education campaigns do not guarantee that every informed individual will avoid activating low energy doors or that every individual is aware of the consequences.

As opposed to relying on one’s empathy or awareness, my proposed upgrade to the modern low energy doors physically deters unintended operators from abusing them by keeping the doors closed. My design is independent of whether or not the operator has been informed: those that are uninformed would also be deterred, which is not possible with awareness and education alone. By no means is my proposal seeking to replace educating people about a trivial way to conserve energy. It is intended to be a supplement to this ongoing cause.

I will build on the existing system design of low energy doors, shown below in figure 1, which involves a power operator, power supply, electric locking device, door, and actuators (activation devices) (Rubenoff, 2021). An actuator may be wireless, so the system design for such variations of low energy doors differs from the system design shown in figure 1. For the purpose of this proposal, I will only focus on the wired variation; however, the implementation for the wireless version should be similar in the overall system design.

My project will involve rewiring hardware of the existing low energy door design to introduce new components as well as a software component. Figure 2 introduces my proposed components: the camera and embedded device. The embedded device can be either a Raspberry Pi or a NIDIA Jetson Nano if the machine learning model becomes more computationally intensive (Brock et al., n.d.). The system will be rewired so that when the actuator is pressed, it would send a signal to the embedded device the moment it has been pressed. Depending on which side of the door the actuator was pressed, the camera on the actuator's side would take a picture of the user. The picture is processed by the embedded device and a signal is sent back to the actuator with the decision of whether or not the door should be opened. These new components can be treated as an extension of the actuators while the rest of the original system can be treated as a black box.

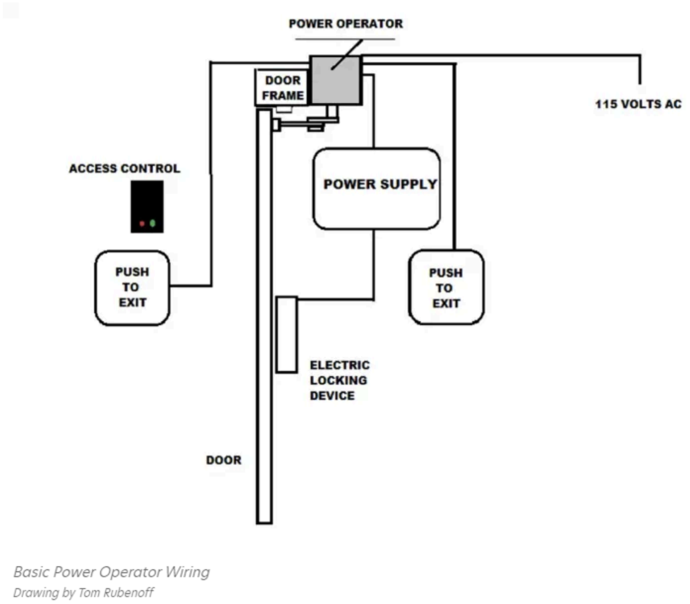

Figure 1. Basic Power Operator Wiring by Tom Rubenoff

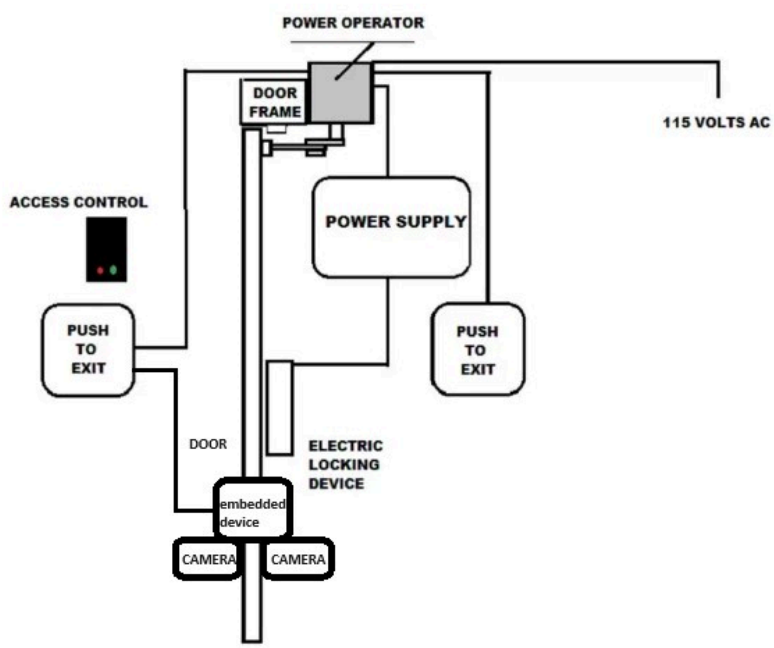

Figure 2. Proposed system design with cameras and embedded device

The software component is responsible for training a machine learning model. I will use python as the primary language, supplemented by libraries such as Scikit-learn, TensorFlow, and

Matplotlib, to use transfer learning to adapt Inception-V3 and other pre-trained models (Manasa, n.d.) for the purposes of recognizing people who needs assistance opening doors. I will use the images online of people with disabilities or carrying heavy objects for both training and testing of models.

I can demonstrate the value of this project after the models reach at least 95% accuracy on the testing set. At this point, I can connect the model to the camera to test whether the trained models are able to identify individuals that need assistance opening doors from the pictures the camera provides. Once that phase of testing is complete, I can proceed to the last phase, connecting the embedded device with the image recognition model and cameras to a low energy door.

STS Project Proposal

Solyndra was created in 2005 as a solar photovoltaic company that claimed to produce cylindrical solar panels that generated more electricity than the typical solar panel at a lower price (Williams 2023). It had convinced investors such as RedPoint Ventures, CMEA Capital, and RockPortCapital to invest one billion dollars into their startup as well as the Department of Energy (DOE) to provide them with a $535 million loan (Korosec 2011). This immense support became a massive catastrophe as Solyndra filed for bankruptcy in 2011 and the DOE recovered less than $30 million of the $535 million.

Some sources that try to explain this catastrophe often cite the price drop of natural gas and polysilicon. This drop undermined one of Solyndra's main selling points: it did not require natural gas or polysilicon when they were expensive. After the price drops, other solar panels could be produced cheaply with the reduced cost of these materials (Williams 2023). Other sources point out that these cylindrical solar panels were not suited for residential areas or large utility-scale sites and that their cylindrical shape, with little benefit to energy production, created manufacturing complexity that increased production cost (Pell 2011).

These are all valid reasons to explain the failure with different technical factors of the network that caused the collapse of Solyndra and the loss of $1.5 billion dollars. However, providing reasons to explain failures from solely a technical perspective fails to capture the collapse of a complex network as a whole. There are also non-technical factors that are part of this network that contributed to this catastrophe: competition from Chinese solar companies like Suntech and Trina Solar (Korosec 2011), Solyndra officials providing inaccurate information and creating unneeded spendings (Williams 2023), and the DOE not being careful with the documents they were provided (Fehrenbacher 2015). Interactions within the network of technical actors and the non-technical actors is what truly caused this disaster.

Only considering the technical actors and ignoring the impacts of non-technical actors provides a limited view into the overall failure of this complex network. I propose that Solyndra's network was destabilized due to interactions between technical and non-technical factors including international competition, reduced price for typical solar panel materials, limited market, manufacturing complexity, Solyndra officials' misconduct and reckless spending, and the DOE failing to carefully inspect the documents provided to them.

I will use the Actor-Network Theory (ANT) to frame my proposed argument. ANT was introduced by Michel Callon, Bruno Latour, and John Law. It explains that different types of factors, whether it is social, economical, natural, or technical, can contribute equally to technological change. These factors and actors can bring upon this change by creating connections with each other to form sociotechnical networks (Cressman 2009). To enable my analysis through ANT, I will reference news articles as well as a DOE's investigation report into Solyndra providing misleading information (Energy.gov 2015).

Conclusion

My technical project proposal will outline a design to upgrade modern low-energy doors to reduce the energy consumption of buildings by preventing unnecessary operation of the doors. My STS project proposal will analyze the collapse of Solyndra through an analysis using the STS framework Actor-Network Theory to identify the different technical, social, natural, and economic actors and the network they formed that led to Solyndra's failure to be widespread and its eventual demise. I aim to inform my technical project with the analysis done in my STS project to create an innovation that is both technically sound and be smoothly integrated into different public buildings to help reach the National Climate Task Force's 2030 goals.

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