Project ID: 351

SR - Engineering: Energy, Materials, and Transport

Ethan Sun

Water Harvesting with Hydrogel

The ultimate goal of our project is to find the best way, using hydrogel, to convert water vapor from the atmosphere into drinkable, pure water. In fact, the amount of water in the air is 10% of the water in all of earth's lakes, which makes the research very promising. In places where water is hard to come by because of dryness or poverty, like the Californian deserts or the Sahara, this project will make water more accessible. It took lots of testing to find the right recipe for the hydrogel. There were many recipes that were tested, each with different amounts of chemicals, until I found the hydrogel that was able to absorb the most amount of water. The original design also did not include the use of mica to release water from the hydrogel, but only used mesh. I tested the effectiveness of the hydrogel using two different ways: first, by submerging it under water, and second, by leaving it outside in the real world. One key change in the recipe after using the first method was the removal of the chemical PSA because it did not help the hydrogel to absorb water. Although the final design is not done yet, the hydrogel portion of this huge project is very close to being done. The next step is to collect the water from the hydrogel, and also combine everything (hydrogel, mesh, mica) into a container that is more accessible to others.

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Anna Luo

Multi-Purpose Shelter for the Homeless

Thousands of people are killed or hospitalized every year due to severe weather conditions. Unsheltered homeless people looking for safety during the winter and lost hikers are just two examples of those who are at risk. Therefore, my project, ShelTable, aims to provide a realistic solution that not only provides overnight housing for everyone, but also serves as recreational tables for the community.

My initial prototype resembled a standard picnic table set with two benches and a table in the middle. The sides of the table were able fold down and form a roof, sheltering those sleeping underneath. This city-friendly design can easily replace pre-existing picnic tables and would avoid occupying extra space.

Following further research and several revisions, I altered this design to be more protective during storms and heat insulating by adding additional walls on the sides of the table and refining the transformation mechanism.

My prototype can easily transform between the table set and shelter. It successfully formed a secure shelter that was comfortable for those sitting outside during the day and also for sleeping inhabitants at night. To further improve this design, I could work on upgrading the insulation within the shelter.

ShelTable is an innovative shelter that can be easily integrated into cities across the nation at the benefit of not only those in danger, but also other civilians as well.

Project ID: 353

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Rahul Rao

Algorithms for Evolutionary Aviation Network Flow Optimization Using Topological and Demographic Features

Air transportation has grown rapidly across the United States, especially after the deregulation act of 1978. Demand for air transport, heralded as an engine of global economic growth, is expected to soar in the coming years. This has increasingly led to delays and deterioration in service across the National Airspace System (NAS), creating a pressing need for new transportation planning and analysis tools. In this project, I develop a novel methodology for planners to optimize air network flows. By extending tools from classical network theory to consider features such as population, and applying this to big data, the project gives practitioners a rich toolkit to analyze complex air transport networks and to consider the effects of hypothetical interventions.

I build a network of airports enriched with demographic and topological data and use Dijkstra's shortest path algorithm to determine centralities' importance values of airports. To facilitate counterfactual analysis, I then calculate removal importance: a measure of each airport's impact on the overall network by comparing centralities before and after a node's removal.

To evaluate effectiveness, I calculate both weighted and unweighted centralities, the former applying my scheme taking population data into account. The weighted centrality achieves a significant 15 percent reduction in root mean square (RMS) error value in predicting ground-truth importance values compared to the unweighted centrality. A visual representation of weighted centrality and removal centrality on a U.S. map reveals that popular airports possess larger importance values. However, some counterintuitive outcomes, such as some popular airports being neglected, are observed due to the size of the hubs and the distinction between removal and centrality importance.

Transportation planners and researchers alike can use this methodology to optimize air traffic network flows, especially during emergencies like temporary airport disruptions caused by weather. Moreover, the project contributes to the field of transportation planning and management, demonstrating the potential of using graph theory to create rich network models. It is also an important methodological contribution in operations research, and the approach herein can be extended to other network analyses.

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Jocelyn Zhang

Enhanced Photoluminescence Performance of Porous Silicon Quantum Dots for Bioimaging Application

Bioimaging is one of the most versatile visualization methods in biomedical research and an important in-vivo diagnostics method for cancer treatment. Due to its biodegradability, low toxicity, and intrinsic photoluminescence, porous silicon based quantum dots have attracted considerable attention. However, the quantum dots have stability limitations, and tend to photobleaching off during operation, which has been the main restriction for its bioimaging applications. Could silicon dioxide be formed to improve the photoluminescence stability of porous silicon quantum dots? Can the heat be used to recover the photoluminescence after the quantum dots photobleaching off?

The experiments were completed on 4 different phases. The porous silicon was made by etching process. The porous silicon quantum dots were oxidized in an oven in order to thermally form an silicon dioxide shell coating. Photoluminescence intensity and quantum yield were measured on porous silicon with and without SiO_2. A test setup was established to measure the photoluminescence intensity and intermittency issue by photoluminescence spectrometer . The photoluminescence recovery experiments were conducted by applying heat at elevated temperature for different lengths of time and measured by photoluminescence spectrometer.

An effective test method has been established to reliably measure the porous silicon quantum dot photoluminescence intermittence phenomenon. Silicon dioxide coating is formed as a core shell on porous silicon after heating at 250C for 5min which improves stability, while also achieving a high quantum yield and photoluminescence. Silicon dioxide coating improved the photoluminescence efficiency and stability of porous silicon quantum dots After heating at elevated temperature at 170C, the photoluminescence of porous silicon is recovered from photobleaching issues.

The photoluminescence stability and efficiency of porous silicon has been improved after SiO_2-Si core shell structure formed. The results show that the heating could reliably recover porous silicon photoluminescence bleaching off issue. It can be concluded to accept the hypothesis, that the silicon dioxide could increase porous silicon based quantum dots photoluminescence emission efficiency and stability. The increased temperature could recover the quantum dots photoluminescence intermittency issue.

Project ID: 355

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Marcus Catanzaro

Optimizing Heat Transfer of Cooking Surfaces Using Various Strategies of Temperature Control

It is difficult to efficiently heat a griddle for cooking. When heating a griddle people often let the cook surface get too hot, burning food. Often, they turn it down, resulting in the surface becoming too cold for cooking. These changes in temperature take significant amounts of time making it difficult for people to judge how the cook surface is behaving. Studying this problem incorporates heat transfer; the energy transferred between bodies as a result of changes in temperature. The temperature profile of the heat source over time is the easiest way to control the temperature of the cook surface. I hypothesize that there is a way of achieving the proper temperature for cooking that is faster than setting the burner to the desired temperature for the griddle. Specifically, I propose that a temperature profile consisting of an initial high temperature followed by a low temperature before being set to the equilibrium temperature would result in a shorter time to heat the griddle.

When attempting to calculate the transfer of heat, I discovered that the change in temperature through the thickness of the griddle was almost instantaneous compared to the change across the horizontal surface of the griddle. With that discovery in mind, I reduced the heat transfer problem to a single dimension. I created a numerical model of the heat transfer of a griddle using Python. The model was then used to simulate over 700 unique temperature profiles. These profiles included various temperatures for the high and low segments, as well as multiple time lengths for each segment.

With a constant temperature the griddle reaches equilibrium in 30 minutes. While over 60 permutations showed a major reduction in time, many more resulted in the griddle taking longer than 30 minutes to heat. Some permutations of the temperature profile were able to reduce this heating time to under 15 minutes. However, these improvements in heating time required very specific conditions which could make it difficult in practice.