ENGINEERING
HONORS PROGRAM
UNIVERSITY OF MICHIGAN

Solar Array Analysis Suite

Honors Capstone

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Advised by Professor A Harvey Bell, IV

12/09/21

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Background

- Project done in service of the University of Michigan Solar Car Team
- Design, build, and race the world's fastest solar-powered vehicles
- Traditionally race in the World Solar Challenge - cancelled in 2021
- Team will instead attempt an alternate event during 2022
- Array (solar cells) even more important due to the increased distance

Background

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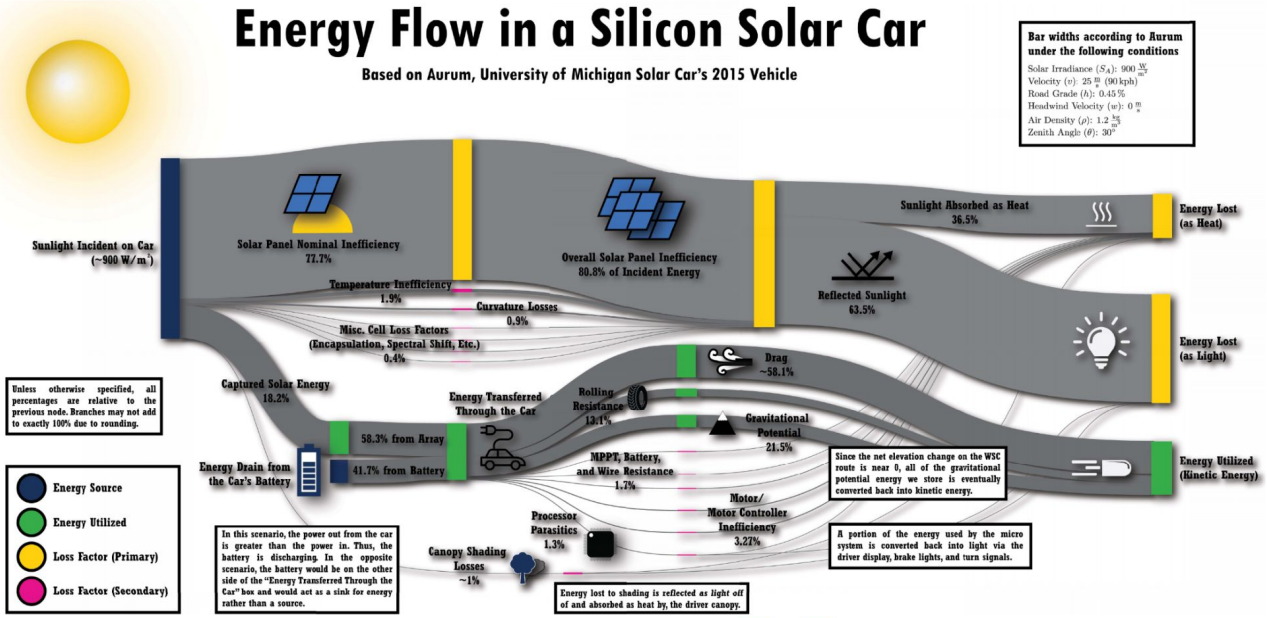
Introduction

- Team needs software to rapidly prototype/analyze array designs
- Must integrate directly with current array design methods
- Include as many sources of inefficiency as possible
- Provide clear/intuitive data readouts to inform array design decisions

Summary

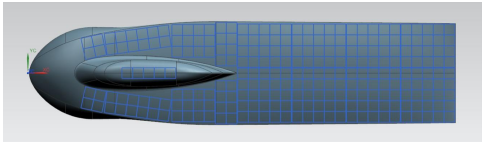
- Four MATLAB modules, one Unity executable
- Integrates with Siemens NX and the team's own data analysis tools
- Able to analyze array on per-cell basis
- Tracks thermal, cosine (curvature), shading, MPPT losses
- Tracks total system efficiency, predicts power brought in by the array

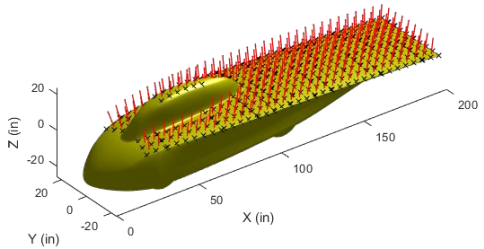
First Principles

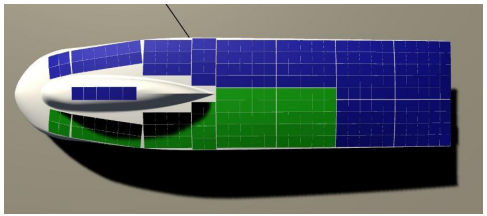


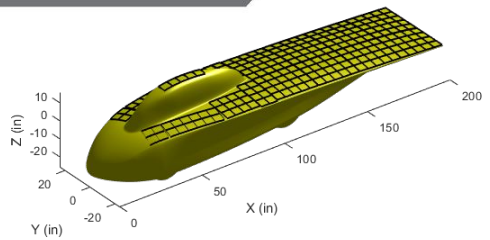
Process

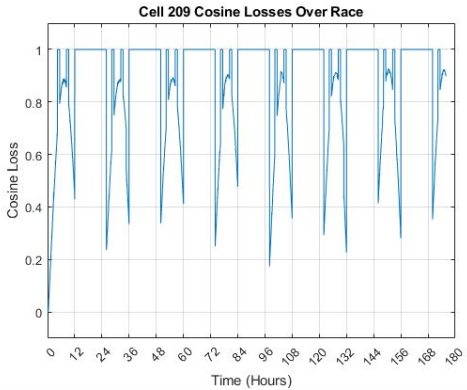
- Array designed in Siemens NX
- CAD files imported to MATLAB
- File analyzed, exported to Unity
- Unity data re-imported to MATLAB
- Final analysis run, results analyzed









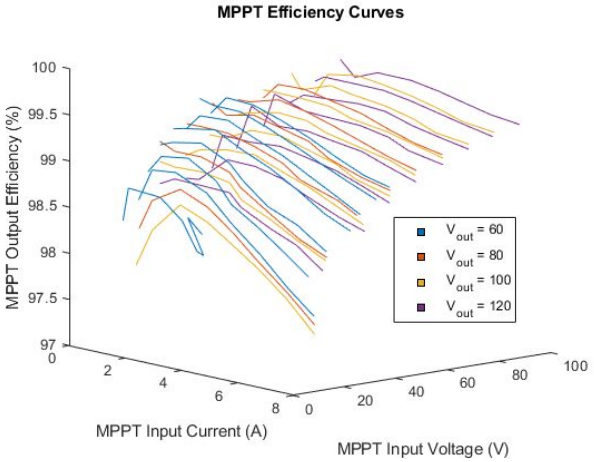


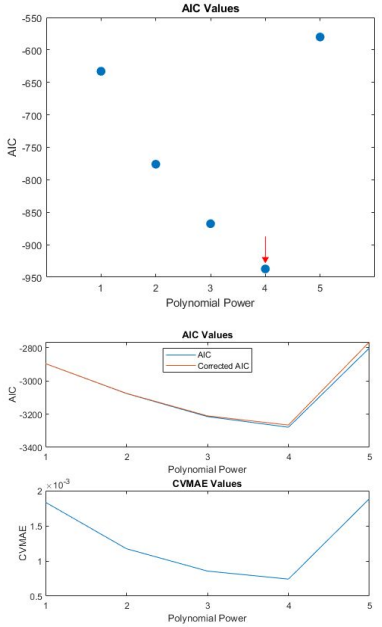
Losses Considered

- Base cell efficiency (can include encapsulation)
- Approximated thermal losses
- Shading losses modeled over a race
- Per-cell cosine losses modeled over a race
- MPPT efficiency model

MPPT Model

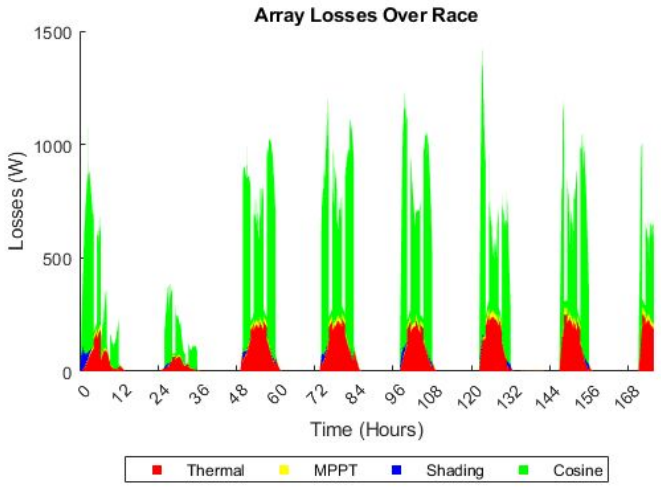
- MPPT model created via a 4D hyperplane fit
- Specific model selected via Akaike Information Criterion
- Choice of model verified via Corrected AIC and CVMAE
- R^2 value of 0.9567

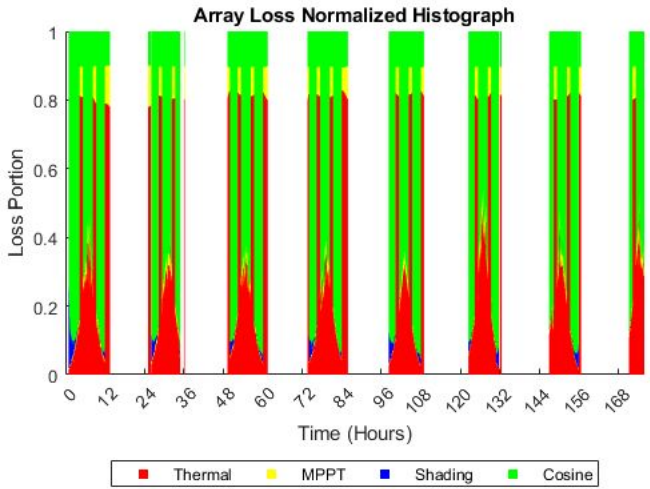




Preliminary Results

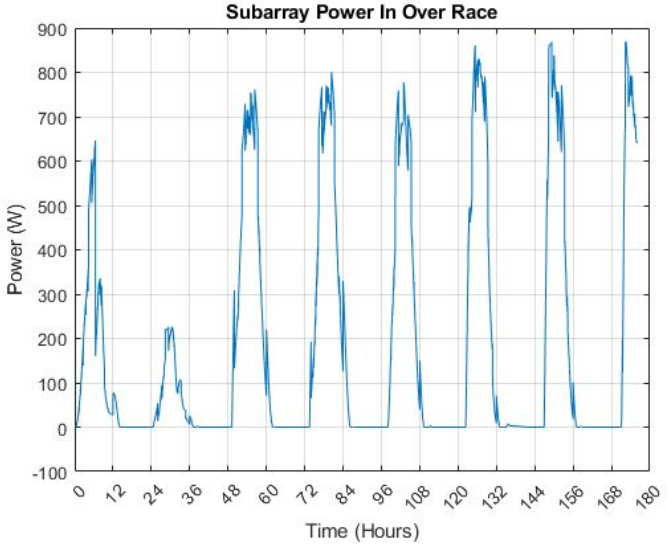
Example System Efficiency: 18.61526%

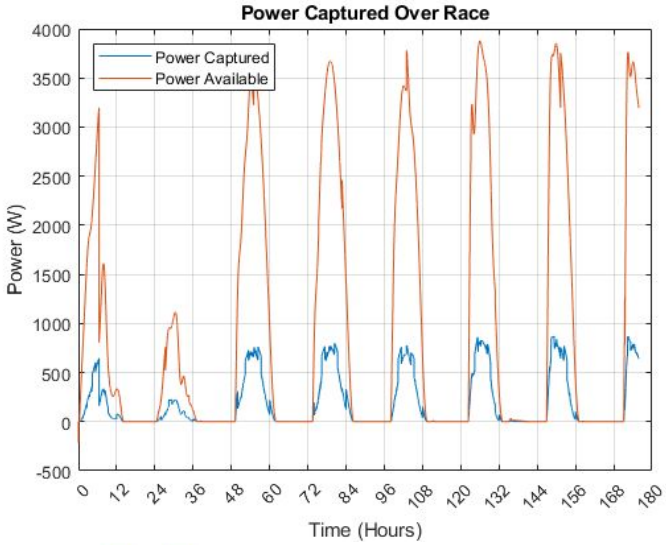




Preliminary Results

Example Average Sunny Day Power: 687 Watts





Future Work

- Improve thermal loss model to work dynamically
- Add bypass diode model to enable greater per-cell shading analysis
- Port Unity shading simulator to MATLAB, create fully integrated suite
- Incorporate battery/motor models to simulate entire electrical system
- Use test data from upcoming summer to verify suite results

Special Thanks

Ian Bertram - Unity programming and design, data gathering

Ibrahim Syed - Projected race file creation

Dominik Kerschbaum - Siemens NX array design

Gabriella Teodoru - Siemens NX array design

Bennett Mejia - Siemens NX array design

Samantha Romano - Siemens NX aerobody design lead

UMSCT Aerodynamics Division - Siemens NX aerobody design

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Thank You

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