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UAS Imaging Path Planner for Heliostat Canting Assessments

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Challenges & Contributions

- An autonomous imaging system mounted on an unmanned aerial system (UAS).
- The UAS is used for developing a fast and accurate tool for assessing the heliostat's canting quality.
- The UAS **path planning** influences the **quality** of the captured images.
- The **quality** of the images affects the **accuracy** of the canting error analysis.
- In this research work, we propose a low complexity **heuristic-based** approach of planning the UAS's path.

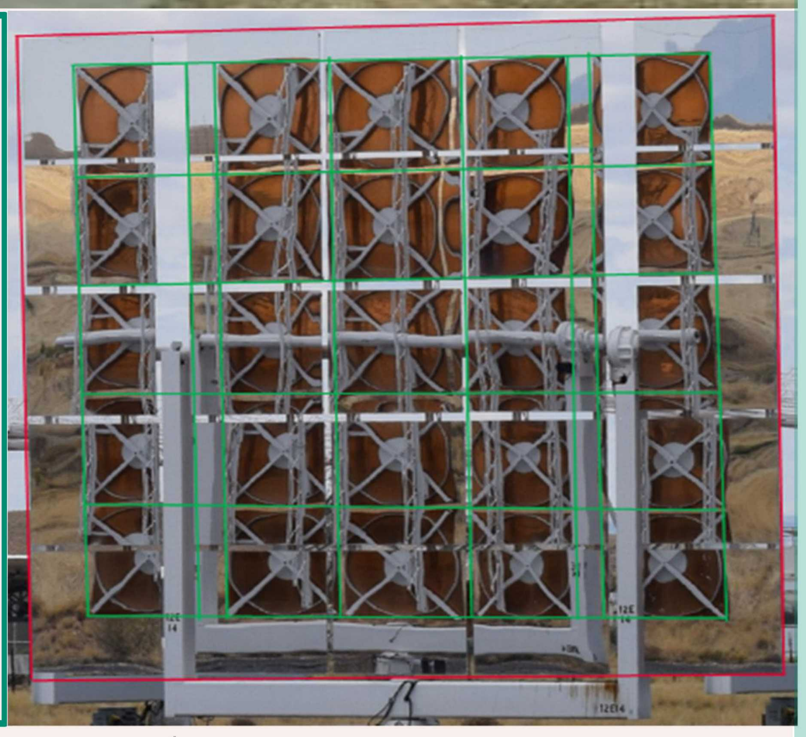
UAS Imaging System

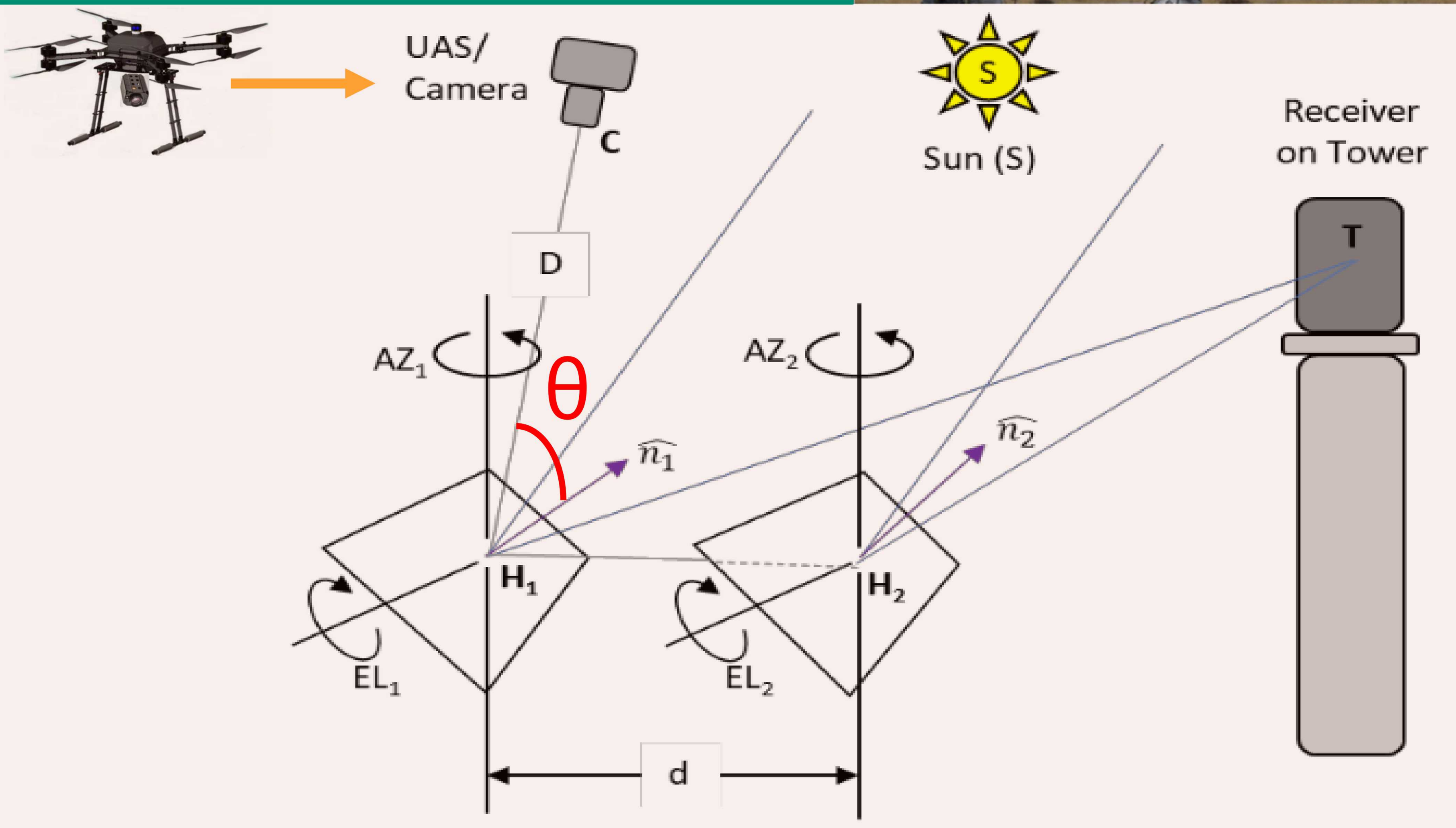
- The UAS imaging system collects images on in-situ or offline heliostats, and the processing code analyzes the images for canting error estimates.

The UAS position is determined by a separate software component that is developed by Sandia.

UAS position dependencies:

- ➢ *Heliostat Orientations.*
- ➢ *At least 60% coverage of the reflected target image.*





- The view angle θ influences the quality of the captured images
  - ➢ $\uparrow \theta$ → less pixels in the direction of the perspective.
  - ➢ ↓ UAS energy availability → less assessed heliostats.

UAS decision-making objective:

- Selecting heliostat pairs with low view angles, i.e., θ.
- Maximize the numbers of assessed heliostats, i.e., minimize UAS energy consumption.

UAS Path Planning: $PP \triangleq \{(x_0, y_0, z_0), \cdots, (x_i, y_i, z_i), \cdots, (x_N, y_N, z_N)\}$

- N number of heliostats.
- (x_i, y_i, z_i): the UAS position for assessing the h_i heliostat.
- $V = \{h_j : j < i\}$: the set of already assessed heliostats.
- $P = \{(x_k, y_k, z_k): k \leq N, h_k \notin V\}$: not assessed heliostats' positions.

Heuristic Utility Function: $U_{xyz} = w_c * \frac{c_{xyz}}{c_{max}} + w_t * \frac{dt_{xyz}}{t_{max}}$

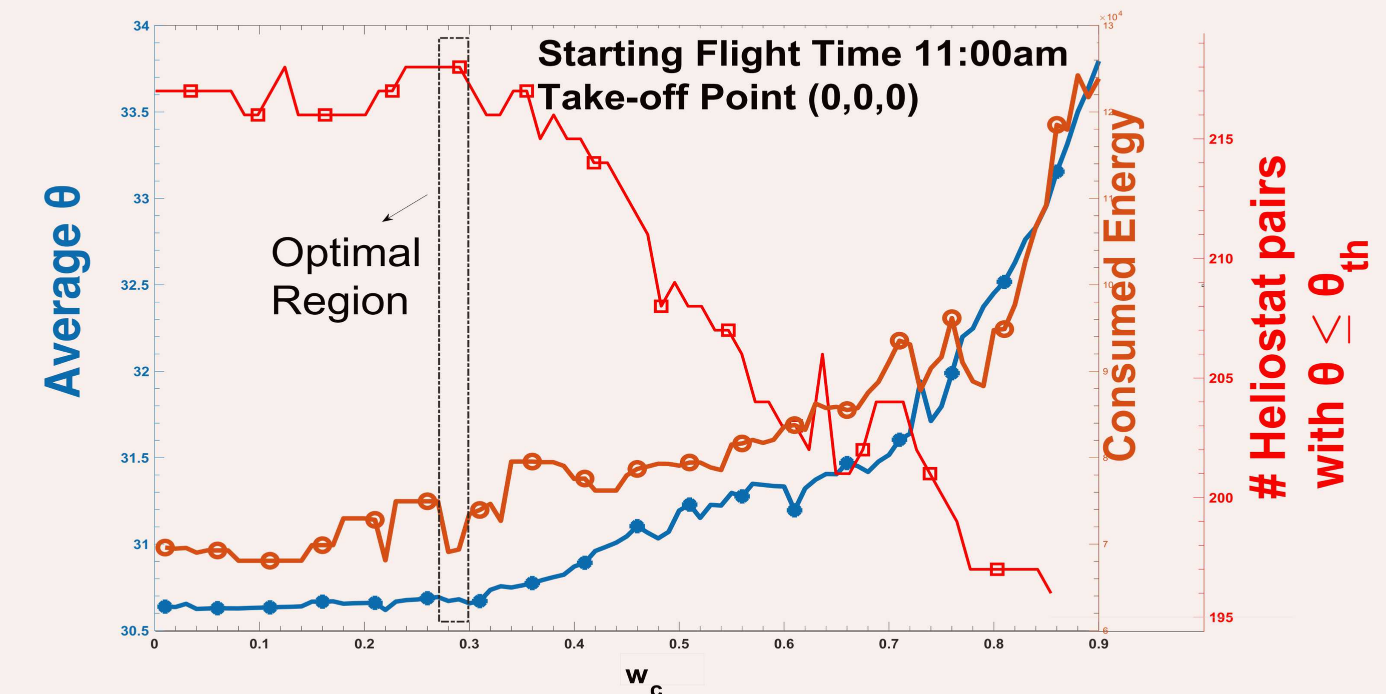
- $w_c, w_t \in [0,1], w_c + w_t = 1$
- c_{xyz} is θ view angle at (x, y, z), $c_{max} = 90°$
- $dt_{xyz} = \frac{||(x,y,z)-(x_i,y_i,z_i)||_2}{v}$, v: UAS velocity, t_{max}: max. flight time.

UAS position software → P → U_{xyz} Evaluation → U_{xyz} Selection

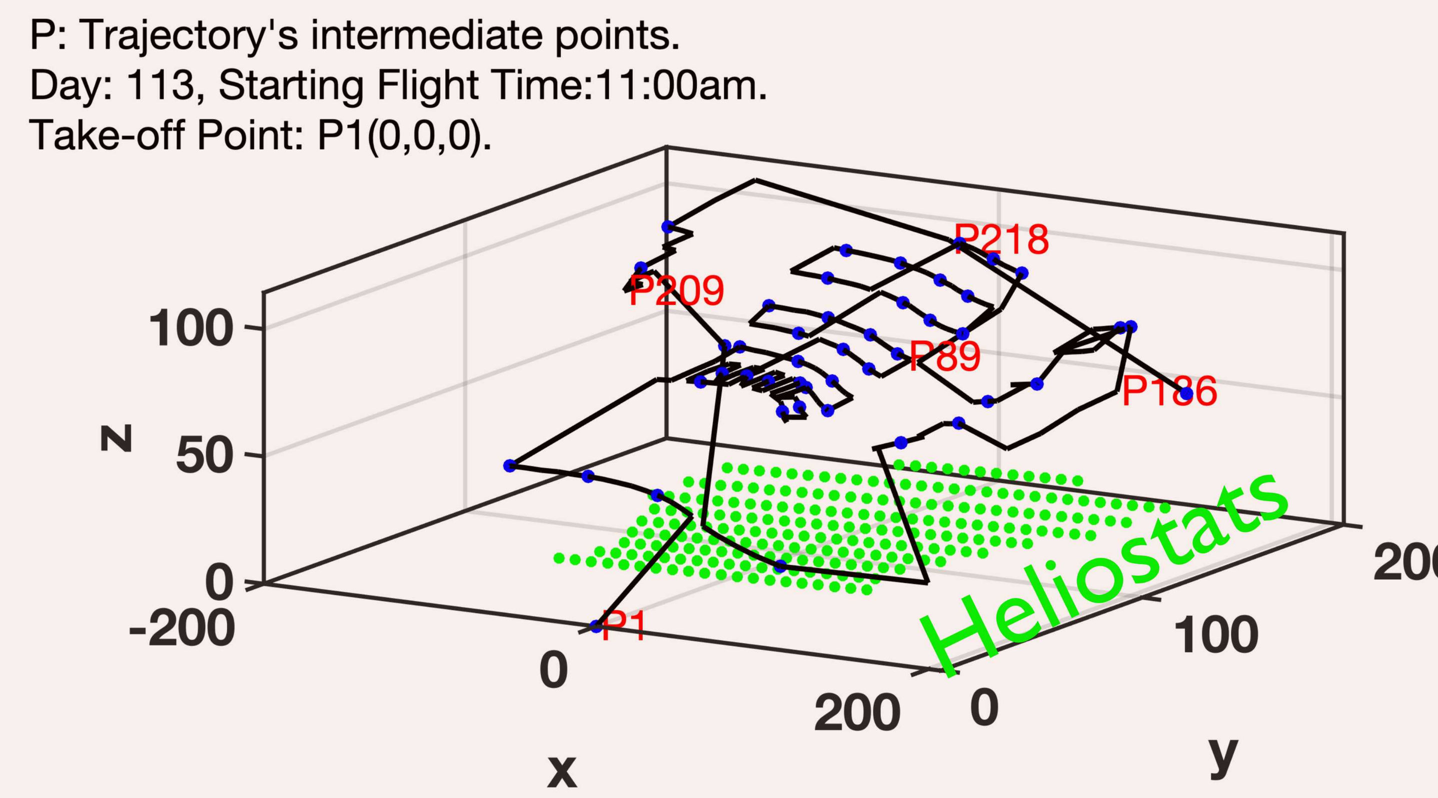
Heuristic-based Approach complexity: $O(N^2 logN)$

Indicative Results

W_c, W_t tuning



UAS Path Planning Trajectory



For demonstration purposes 45 flight path points that correspond to 45 heliostats (out of 218 heliostats at NSTTF) are depicted.

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