ASU Cool Routes

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Introduction

- Pedestrians in desert cities face significant risks of heat stress and illness, particularly when exposed to prolonged periods of direct sunlight and high ambient temperatures during the summer months
- Navigation tools such as Google Maps suggest shortest walkable routes but do not prioritize thermal comfort and minimize heat exposure
- We present ***ASU Cool Routes*** – a tool to identify the coolest route from an origin to a destination on ASU's Tempe campus
- ***Cool Routes*** is an interactive website for the ASU community to navigate the main campus while maximizing shade and minimizing average experienced heat load (Mean Radiant Temperature, MRT)
- The novelty of the tool lies in its capability of providing MRT data in real-time and for times in the near future (hourly 1-day forecast)

System Architecture

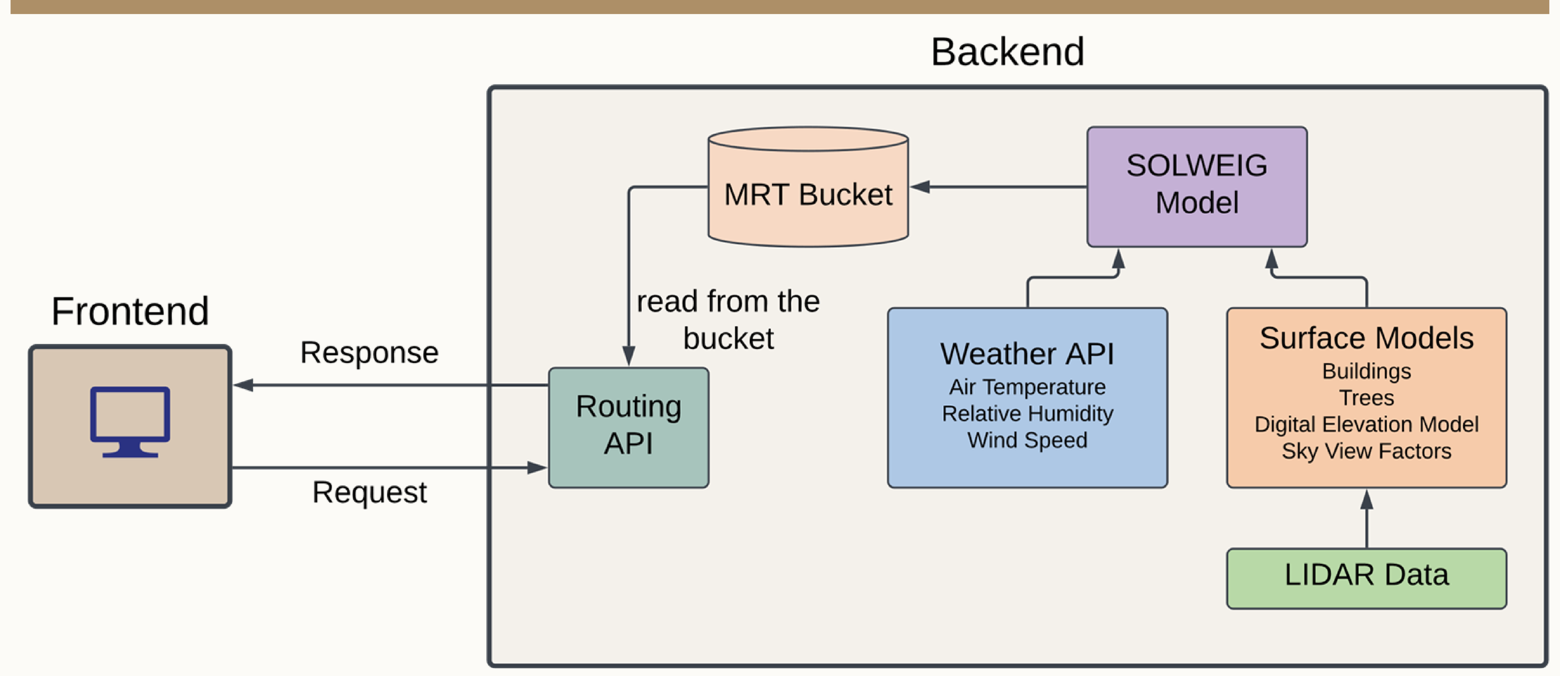

Fig. 1: System architecture of the ASU Cool Routes application.

- The tool has a frontend and backend (Fig. 1). The backend has two components: a Routing API and SOLWEIG, a radiation model to simulate MRT [1, 2]
- SOLWEIG calculates MRT using 1-m resolution surface models derived from LiDAR data and hourly meteorological forcing provided by the Oikolab weather API [3]
- Hourly MRT maps are pre-computed overnight based on Oikolab weather forecast data (air temperature, humidity, wind speed) for the following day
- The Routing API accepts GET requests from the frontend when a user selects a date, time, and an origin and destination building on campus. It utilizes Dijkstra's shortest path algorithm [4] to identify the coolest route, using MRT as impedance along a network of walkable paths (Fig. 2).
- Upon request, the website displays the coolest route, shows the average MRT exposure, and the length of the route
- The beta version of the tool spans latitudes 33.4294 to 33.4097 and longitudes -111.9178 to -111.941 and features 171 landmarks on campus

Beta version of the tool

- Try out the tool by scanning the QR code or by visiting https://coolroutes.sensableheatscapes.com/

Cool Routes Frontend

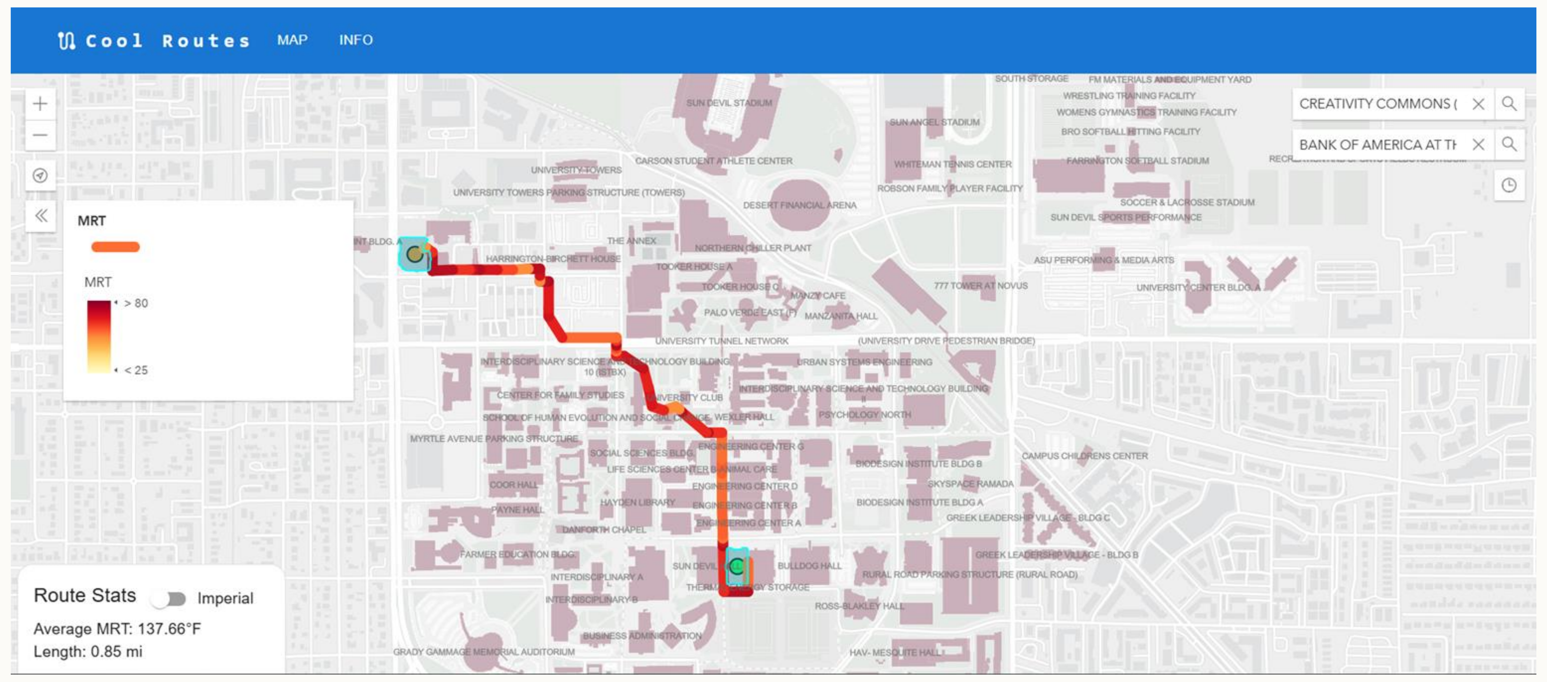

Fig. 2: Interactive map of ASU's main campus, displaying the coolest route from Creativity Commons to the Brickyard on 15th Junel, at 3:00 PM.

Analysis of Simulated Routes

- 500 origin-destination pairs were randomly selected to generate typical walking paths; paths had to have a minimum length of 500-m
- Hourly cool and shortest routes between 6:00 AM and 4:00 PM were calculated for one sunny day each month between October 2023 and September 2024
- This process generated 66,000 unique data rows, representing the different route-date-time combinations
- Routes were analyzed with respect to average MRT reductions along the coolest vs. shortest paths, by time of day, season, and route length

Results

- The shortest route was the coolest for 14.58% (9,621) of the combinations
- The average reduction in average MRT was 10.35% on coolest routes compared to the shortest
- Cool routes were on average 4% longer than the shortest routes
- Fig 3. shows that average MRT decreases in the morning and starts increasing at noon. However, the coolest route ensures a lower exposure compared to the shortest route

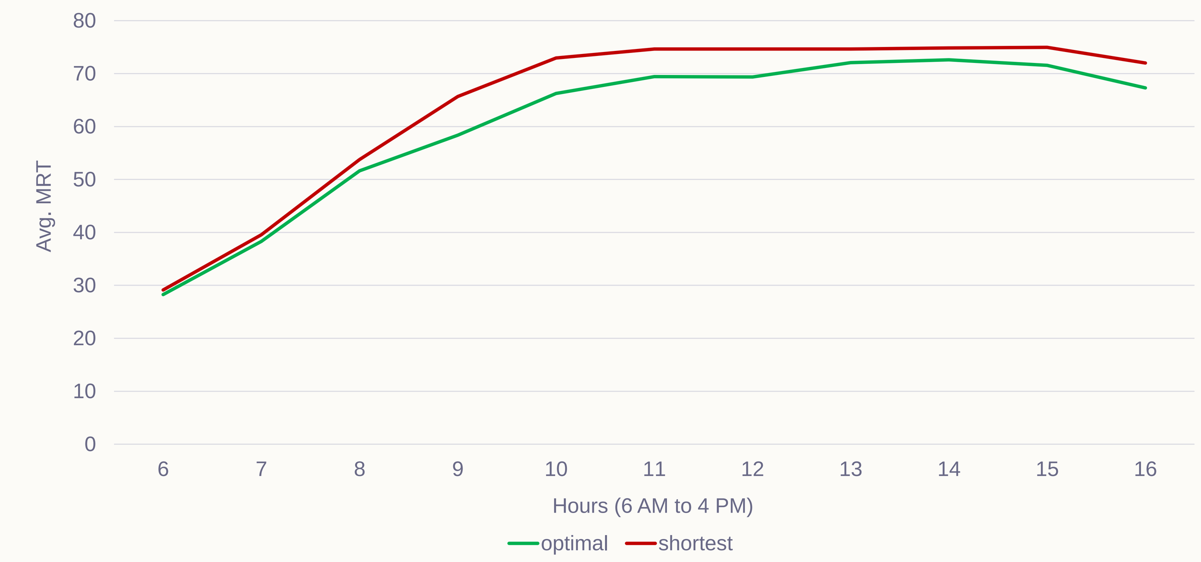

Fig. 3: Average hourly MRT for the coolest and shortest route over the time from Memorial Union to Brickyard Engineering on 15th June, 2024.

Results

- The number of samples where the average MRT of the coolest route is lower than the shortest route is nearly the same throughout the day (Fig. 4)
- For all months, the number of samples where the average MRT in the coolest route is lower than in the shortest route is nearly the same, demonstrating that the tool is useful year-round (Fig. 5)

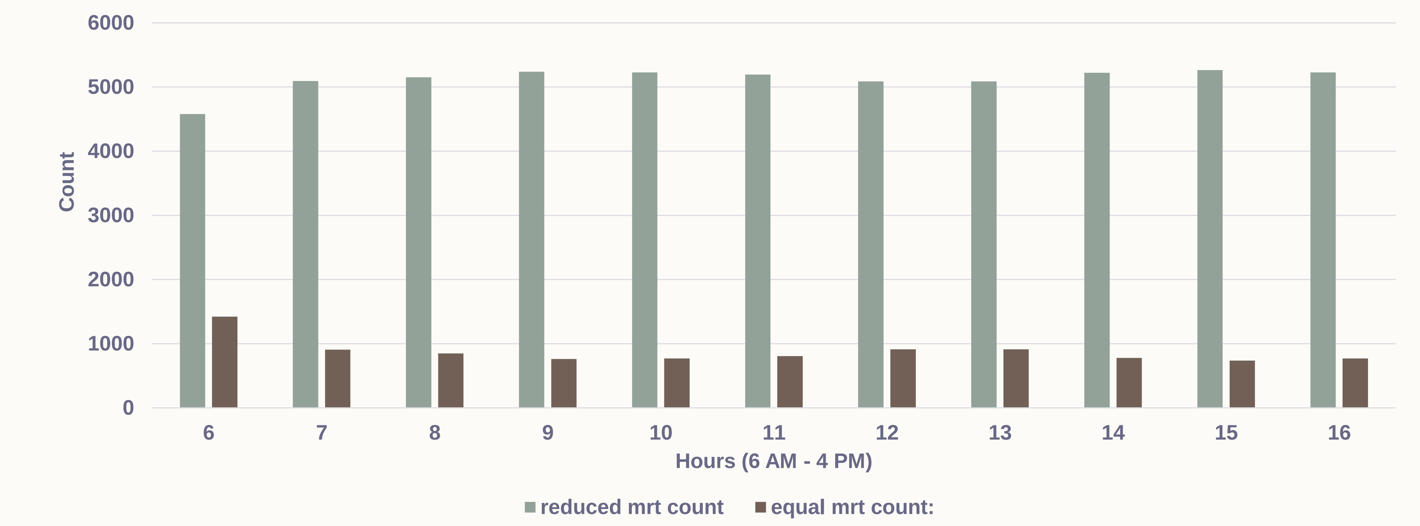

Fig. 4: Number of routes with average MRT reduction or no change in coolest vs. shortest paths between 6 AM to 4 PM.

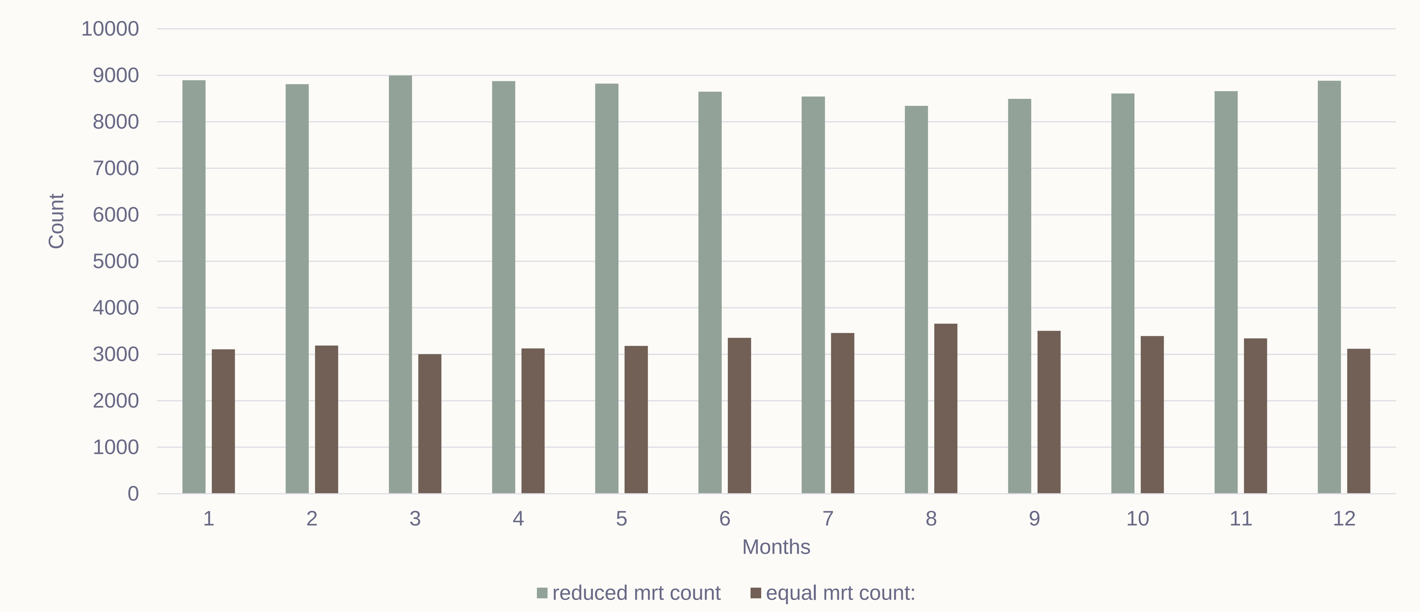

Fig. 5: Number of routes with average MRT reduction or no change in coolest vs. shortest paths over 12 months.

Limitations and Future Work

- The tool is work-in-progress. It is currently hosted on a lab desktop and cannot handle a large number of requests; routing is based on 2020 urban form data; the area is limited to ASU's main campus
- Future work includes a more in-depth analysis of coolest vs. shortest routes; validating simulated routes with in-situ MaRTy observed routes; a usability study; adding more functionality (e.g., adding stops to pick up an iced coffee, adding preferences for walk-only zones, allowing routes through buildings)

References

[1] Lindberg, F., & Grimmond, C. S. B. (2011). The influence of vegetation and building morphology on shadow patterns and mean radiant temperatures in urban areas: model development and evaluation. Theoretical and applied climatology, 105, 311-323.
[2] Buo, I., Sagris, V., Jaagus, J., & Middel, A. (2023). High-resolution thermal exposure and shade maps for cool corridor planning. Sustainable Cities and Society, 93, 104499.
[3] https://oikolab.com/
[4] Dijkstra, E. W. (2022). A note on two problems in connection with graphs. In Edsger Wybe Dijkstra: his life, work, and legacy (pp. 287-290)