Analysis of Cycling Behavior in Bicycle Simulator Studies

Master‘s Thesis of Mak Kei, Tam

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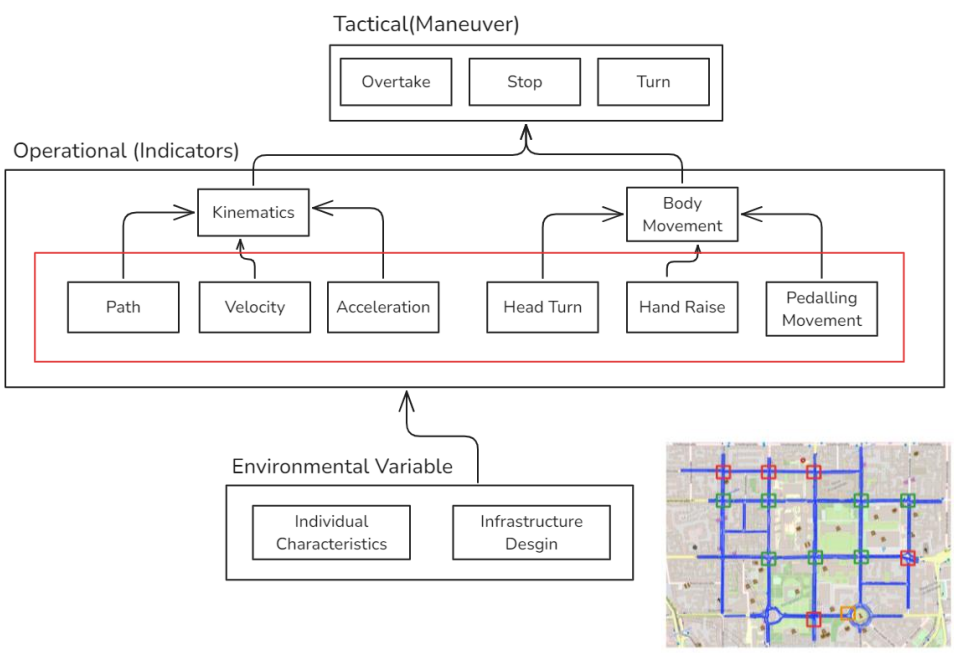


Motivation

How can we design systems—particularly within Autonomous Vehicles (AVs)—that can accurately interpret and predict cyclists’ intentions? While numerous studies have examined the individual cues that indicate how cyclists interact with vehicles, there is relatively little research exploring how these cues interrelate and influence each other.

Research Question

- What behavioral differences exist between cyclists who exhibit certain cues and those who do not?
- What are the spatial and temporal relationships between these cues?
- Does the presence of one cue influence the likelihood of another cue occurring?

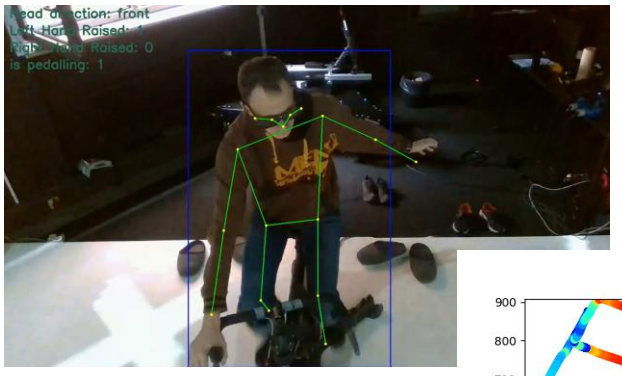
Methodology

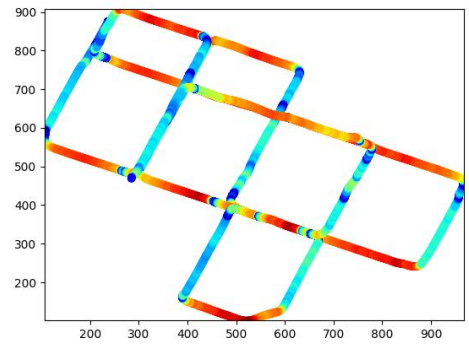
The experiment is conducted in a simulated environment using a CAVE VR setup integrated with a modified fitness bike. Participants ride through a virtual representation of the TUM Main Campus, following predetermined routes.

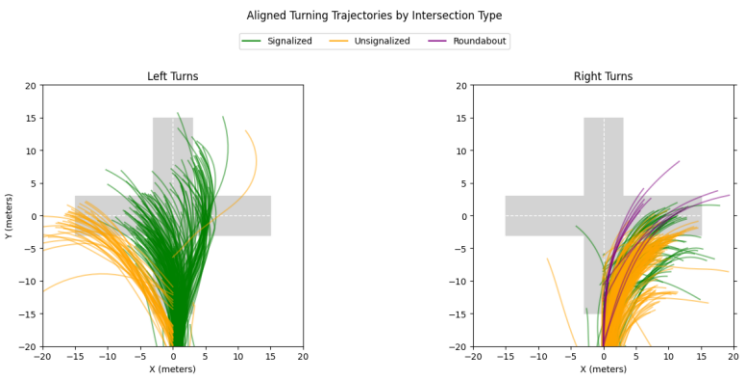
Kinematic data are collected from the fitness bike to capture real-time motion information, including speed, lateral position, and steering. Simultaneously, video footage is recorded to observe participants’ body movements.

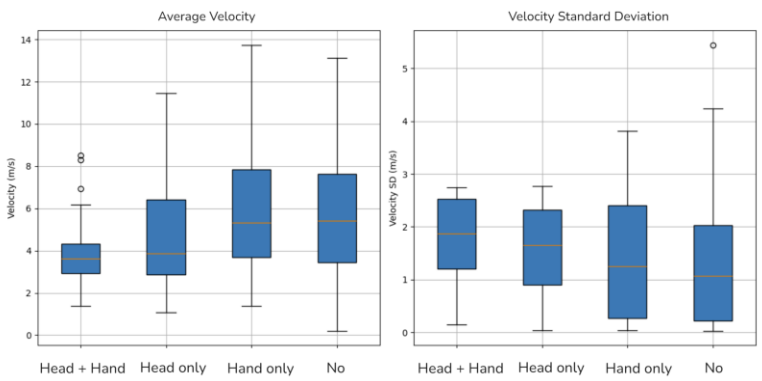
The recorded videos are further processed to quantify changes in body gestures. Using skeleton-based pose estimation, three specific types of body movement are extracted:

- Head Turn
- Hand Raise
- Pedaling









Results and Implications

- Participants tend to make tighter left turn and ride faster at unsignalized intersection than at signalized intersection → Cyclist intention prediction system need to incorporate infrastructure metadata
- There is greater variability in speed and pedaling cadence when participants perform any gesture to signal their intention → when gestures are present, the prediction system should increase the confidence and widen caution zones
- Head-turn and hand-raise often occur together, both in space and time → cues are part of a coordinated signaling pattern, not isolated events
- Participant who raise their hands are 3.3 times more likely to also turn their head. When both gestures are used, they also tend to happen earlier in the turning sequence. → If one gesture is observed, the system can infer the likely presence of the other and predict an upcoming maneuver more confidently.