Analysis of Eye Gaze Data from Cycling Routes in the Oxford RobotCycle Project

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Overview

The Oxford Robotics Institute RobotCycle project [1] collected data about the safety of cycling around Oxford using a custom-built sensor backpack (Fig. 1). As part of these trials, the rider wore a pair of Meta Project Aria eye-tracking glasses [2] to collect their gaze data.

Gaze data has been shown to be a reliable estimator of stress and perceived risk in various domains [3]. Cyclist gaze data was included in the inaugural RobotCycle paper, but many more insights can be gained from the data which the researchers present below.

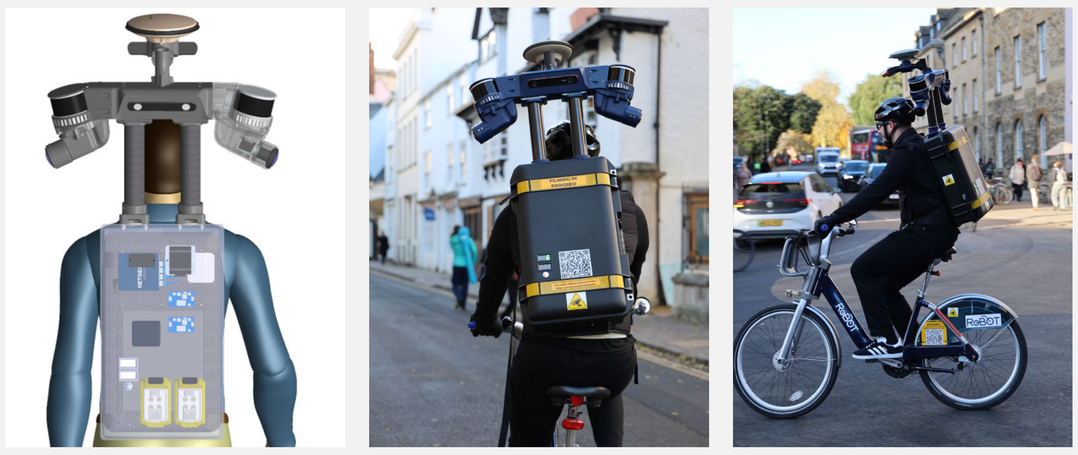

Figure 1. The sensor backpack used in the RobotCycle project [1].

Research Questions

Relying on eye gaze data collected from a pair of Meta Project Aria research glasses, we formulated the following research questions:

- How do cyclists perceive the safety and risk of cycling routes in Oxford?
- Does traffic density have an impact on cyclist stress?
- Are eye gaze methods for cyclists in the wild able to accurately estimate stress?

Methodology

The data was collected over 15 trials over 12 days in the fall of 2024.

Gaze Analysis

Utilizing the raw eye gaze data from the glasses, variations of the common Identity by Velocity Threshold (IVT) algorithm were run [4].

Cycling Routes

Three routes for data collection were selected in Oxford: North, Centre, and South (shown in Fig. 2 from left to right).

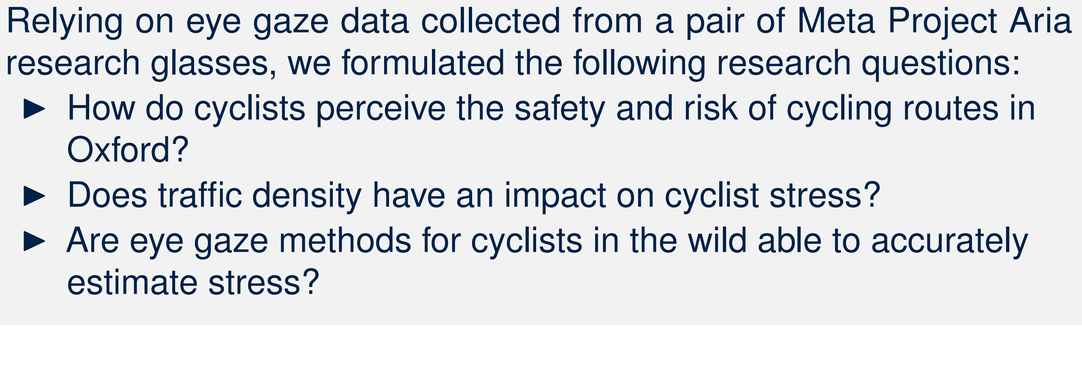

Figure 2. Cycling routes chosen in Oxford.

Traffic Data

Traffic data was collected using the Google Maps API that allows for traffic estimation at a particular time and route.

Incident Self-Reports

Participants self-reported incidents they experienced during the route in the form of a survey, along with how safe they felt overall and the traffic conditions.

Results

Oxford Cycling Safety and Risk

The North route presents the highest risk based on gaze dispersion, followed by Centre and South with statistically similar risk levels.

Route	Our Algorithm $(px/ms)^2$	PyMovements (deg) [5]
North	0.028	19.18
Central	0.022	16.92
South	0.019	17.07

Table 1: Average horizontal gaze dispersion based on the IVT algorithm.

Fixation lengths present a more complicated picture, where averages alone are not sufficient to draw conclusions. This is because both long fixations and extremely short fixations can be signs of stress.

Route	PyMovements Algorithm (ms) [5]
North	594.2
Central	620.4
South	513.9

Table 2: Average fixation length based on the IVT algorithm.

Traffic Density and Stress

Participants self-reported lower traffic density equating to less stress. Via the Google Maps traffic API, the North and Central routes had similar traffic densities significantly higher than that of the South route. The south route was estimated by the IVT algorithms to have the lowest stress. However, we see a statistically similar level of stress for the central route, indicating that traffic density is not the only factor that contributes to stress.

Effectiveness of IVT

The traditional IVT methods of gaze estimation seems to be a sufficient predictor of stress despite the movement and cluttered environment that cyclists face. Fixations, however, prove a difficult metric to draw conclusions from.

Next Steps

- Which sub-routes in Oxford resulted in the highest stress?
- Which other road users elicit the highest stress?
- Do the weather and/or lighting conditions impact cycling stress?

We aim to conduct more trials over the same routes with wearable heart rate and skin responses sensors that will allow us to compare our eye gaze data to more traditional predictors of perceived stress and risk, further clarifying the conclusions that can be drawn from eye gaze data alone.

References

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