Developing a Cyclist 3D GameObject for a Mixed Reality Interaction Framework

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Abstract

Mixed Reality could be used as a safe testbed to capture behavioural data of pedestrians when interacting with other road users, such as cyclists, by introducing a virtual cyclist. However for such real to virtual interaction to be more realistic, the cyclist GameObjects in Unity have to look and move similar to a real cyclist. The existing available 3D cyclist are currently not well suited for such interacting scenarios as they are assets based on prerecorded animations. In this work-in-progress paper we discuss our design of a 3D cyclist GameObject for interactions in Unity. We also explain how we exploit a mixed reality visualisation tool (i.e., Microsoft Spectator View) for our setup, allowing a second person view of a Hololens MR application. We further discuss the scenarios that we consider for a pedestrian-cyclist interaction with this work.

1 Introduction

Milgram et al. [9] classified Mixed Reality (MR) in the Reality-Virtuality continuum as everything that would fall between purely virtual and purely real content. Virtual Reality (VR), which completely immerses the user in a virtual experience, is considered the ideal choice for any safety-centric study. Numerous VR-studies have focused on teaching or studying human behaviour during interactions. It has been shown that teaching traffic rules to participants with VR considerably improves the learning experience [6]. Studies have also shown improvements in traffic behaviour with VR training reducing the number of risky crossings [11].

However lesser works have extended virtual worlds to include cyclists: Sawitzky et al. in [12] proposed a mixed reality simulator as a tool for traffic safety research. In their work they proposed a VR headset with a CAVE setup for the virtual experience of a cyclist. However, our work is more aligned with our recent effort to use MR to study interactions of a pedestrian with a cyclist [4] using simulations. In that work, a setup that allows interactions between a real human wearing a Hololens and a virtual cyclist was demonstrated. While that work demonstrates a concept that could be applied for testing pedestrian behaviour with a cyclist, in this paper we further introduce the design for a realistic virtual cyclist using Unity. We also discuss MR external viewing improvements and pedestrian to cyclist interaction scenarios that are being be considered in our current work.

If the visual appearance of a real cyclist were to be considered, for the given movement along the center of mass; the padels, handlebar and the wheels should sync with the movement of the cycle frame. In most of the Unity AssetStore [1] GameObjects, a cyclist is considered a combined entity with the two-wheeler-frame attached to the rider.

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[1]https://assetstore.unity.com/ (last access 30/1/2023)

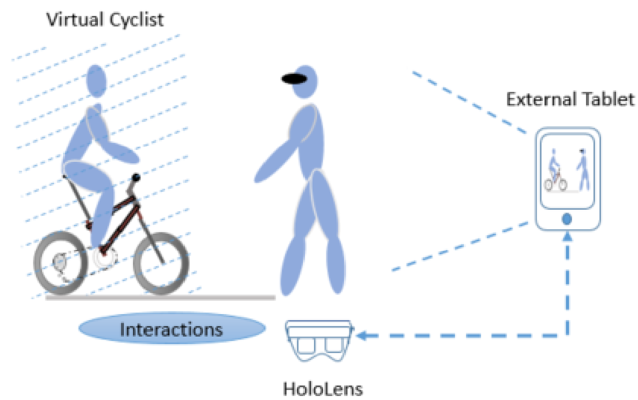


Figure 1: Experimental setup for the framework

In such designs, an animation clip is attached to the cycle that would allow transition to different states (pedaling, stopping, etc.) as defined with the Unity animation state machine [2]. The Unity Engine then moves the cyclist frame to the given position, with the animation controller [2] coordinating all the animated motions. A major drawback in this case is that motions for the cycle frame would be restricted to moving, stopping or changing the directions of motion (turn left, turn right, etc.). The restricted model might not represent interactions accurately as from reality. For instance when a cycle is crossing paths with a person, quick movements like detouring or slowing down should cause changes to handlebar and pedal respectively . This however should also happen for a virtual cyclist. In addition, since the meshes of the cyclist have to be rendered in real time for an augmented view, a complex mesh model might not be best suited here. The 3D model should ensure low complexity for the smooth rendering of 3D content. Many of the GameObjects that are designed for game based scenarios might not suit well for scientific studies in this regard.

While having a realistic cyclist-model is an important component for a scientific framework, it is equally important to have an external viewing camera overlooking the scene. This external view is useful to capture interactions that happen in the MR setup. More so, since a Hololens might be prone to tracking loss due to sudden head movements, such situations could then affect viewing experience of the MR scene. The external camera view would help to visually identify such issues during an experiment. But placing an external viewing apparatus, connected with the Hololens via a network might introduce latency in viewing the hands free MR experience of the participant. Hence the visualisation should connect directly with the Hololens, and also support hand free connection within an acceptable range of operation.

2 Description of the Experimental Setup

As our setup is focused on the MR experience as in Figure 1, this requires the participant to wear a Hololens. We also position an

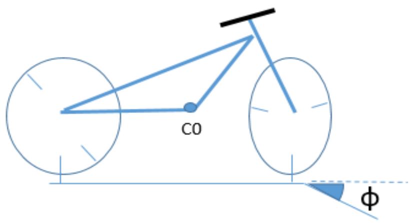


Figure 2: Cyclist 3D model

Android tablet as an external camera source (exC) in this work. This provides a MR second person view of the scene as detailed in the previous section.

In our experimental setup, we use the Microsoft Mixed Reality Toolkit (MRTK) and its supported features for both for the Hololens and exC. The MRTK provides support to get the position of the Hololens device in a local coordinate system. This feature is by virtue used by the toolkit to consistently place virtual content in environments, even with the Hololens user moving in an indoor space. The position information returned by the headset has been proven to have accuracy of $\pm$ 2 cm in experimental evaluations as in [3] . This movement data can be used to get participant trajectories to centimeter scale accuracy while interacting with virtual cyclist. However this accuracy might also be prone to the uncertainty errors caused due to the human head movements.

2.1 Unity Cyclist model and its extension

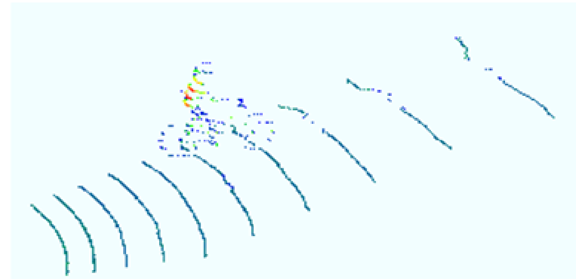
For the interaction of interest within this framework, and to meet the requirements of low complexity and simplicity, we design a Unity cyclist GameObject following the kinematics model of a bicycle.

We propose a 3D Unity GameObject that is a simplified representation of a bike (excluding a rider) as depicted in Figure 2. In this design, we only focus on the center of mass between both the wheels and the angle of the front wheel to the cycle frame. Hence, for any given time sequence, the model can be represented by C0 and ϕ. Our proposed model, however, will not consider the tilting effect of the cycle and thus is a rigid 3D representation of a 2D cyclist.

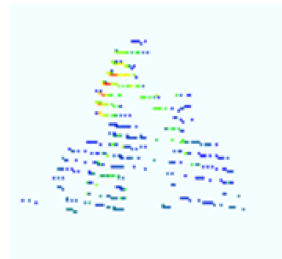
To design and evaluate this model, we have recorded a real cycle dataset using the 3D laser scanner sensor (Hesai PandaXT 32) (Figure 3). The real cyclist positions and motion trajectories extracted from the data would be used to model the Unity cyclist for our future work. We further plan to extend the proposed model to consider the handlebar and pedals as separate entities in our future models.

2.2 Positioning of the external Tablet Viewer (exC)

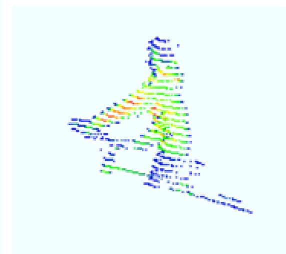
The external camera positioned in the indoor scene will overlook the complete view of the testbed. The Open-source Spectator View toolkit [8] has been used in our proposed environment to provide a second person view of the virtual cyclist as seen by the participant. The multidevice experience provided by the Spectator View is a feature that allows other devices to view Hololens applications from their own view point. During setting up, the exC Android Tablet will use ARCore [5] to estimate its own position relative to the Hololens local coordinate system. The tablet will then establish a socket connection to the Hololens that is worn by the test participant in the field. Following a sequence of operations between the two devices, as detailed by Microsoft, the tablet and Hololens will be in the same coordinate system. The Hololens scene as viewed by the participant, will be transmitted to the tablet allowing for a second-person view of the real scene as augmented with interacting virtual cyclist. This would allow a second person to monitor the interaction experiment, control the motion of the virtual cyclist and also issue new visualisations that would prompt a person to interact with the cyclist differently.



(a) Cyclist motion in pointcloud data



(b) Scan with ground contacts



(c) Cycle frame with handlebar

Figure 3: Real cyclist motion captured using laser scanner.

3 Scenarios for a pedestrian with cyclist-interaction

To exemplify a few scenarios for the interaction framework, we first identify two configurations of traffic conflicts in the context of autonomous vehicles [7] and extend it to cyclists (see Figure 4). The definitions for traffic conflicts are somewhat correlated to the idea of how interactions takes place between road users. Traffic conflicts can be defined as “an observable situation in which two or more road users approach each other in space and time such that a collision is imminent if their movements remain unchanged” [1]. When such conflicts become prominent, an interaction could result from this. Hence, an interactive behaviour is a situation where the behaviour of at least two road users can be interpreted as being influenced by a space-sharing conflict between them. Figure 4 shows some of the common conflicts that could happens between traffic participants.

We choose the Unconstrained head-on-paths (UHP) and Crossing paths (CP) scenarios (Figure 5) in our setup, with the primary participant being a pedestrian. Our choice of the above two scenarios is motivated by having those paths in our scenario in which either participants (real person and virtual cyclist) are visible and free thus maximizing the chances of an interaction.

While our next steps are on cyclist modelling using both the 2D positions and the derived handlebar angles from the real cyclist trajectories, we further plan to experiment the modelled cyclist Unity asset in an indoor setting using the pedestrian interaction scenarios mentioned above.

4 Conclusion

While this paper explains our current work and some of the proposed directions, a few open points, in particular with respect to the design of the cyclist need further discussion. Our current concept design only considers a cyclist without a rider and this might not be completely convincing as a real cyclist. Further, for more realistic interaction scenarios improvements of real world data with virtual content (e.g., benches and virtual trees), giving the participants a feeling of immersion during a MR experiment, should be considered.

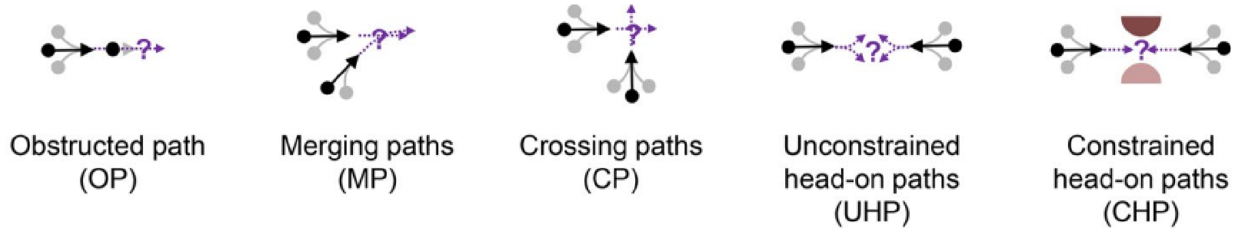
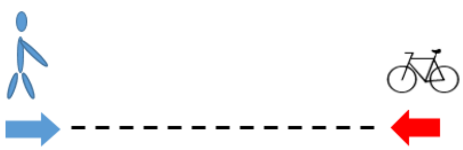
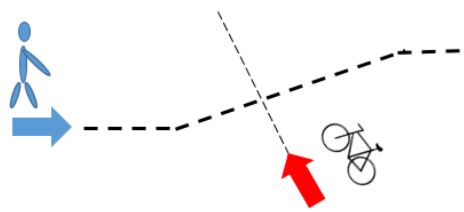


Figure 4: Different types of conflicts borrowed from [7], illustrate the potential interactions that could arise between a pedestrian and autonomous vehicle. Each arrow represents a pedestrian or a vehicle conflicting.



(a) UHP scenario - Unconstrained head-on collision between traffic agents



(b) CP scenario - Crossing paths between traffic agents

Figure 5: The scenarios covered for interaction with pedestrian participant (blue) in conflicting paths with virtual cyclist (red)

Even when our current steps are more to design the cyclist model, the visual appearance (change of facial expression) and reaction of a bicycle rider in mixed reality to a pedestrian encounter might also be interesting. Also the a second person Spectator View would be currently limited to the field of view of a tablet , which could be extended to a static overhead camera positioned to overlook the scene in a future point of time.

Furthermore even with the current works more focused for cyclist interactions from a traffic perspective, it might be equally interesting to see their influence in domains like sports, where a mixed reality approach could be used to improve bicycle performance during cycling marathon or during a relay racing event. This for example can could contribute towards research directions [10] where AR and virtual immersion could have a large impact in sports and serious games.

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