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Pedestrians' motion Through the Eyes of Road Users

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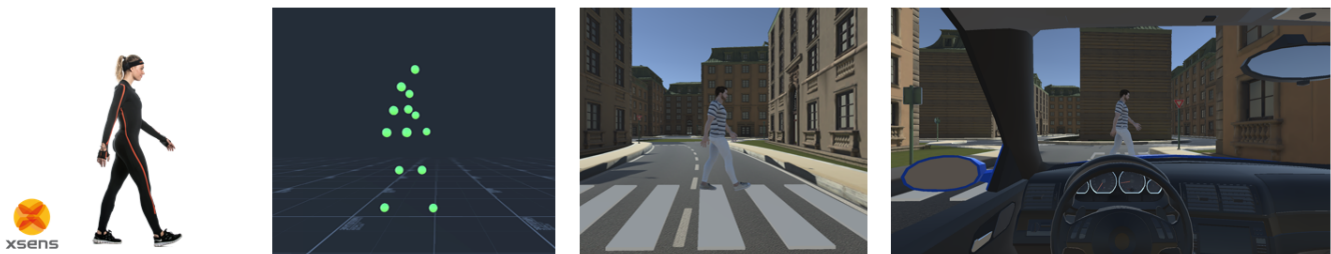


Figure 1: From pedestrian motion capture to contextual psychological experiment passing by theoretical studies on biological motion perception and interception.

ABSTRACT

This work introduces PERCEPT-PIETON, a project aiming to understand through the use of virtual reality and inertial motion capture, perceptual-motor and cognitive mechanisms involved during driver-pedestrian interactions from the driver's point of view. We are particularly interested in how drivers regulate their behaviour and predict pedestrian's intentions based on individual (age, gender, ...) and behavioural (walking speed, trajectory, ...) characteristics of the latter. The objective is threefold : (i) a theoretical scientific contribution to obstacle avoidance literature; (ii) applied scientific knowledge for public decision-makers; and (iii) the creation of a free access library of biological pedestrians movements.

KEYWORDS

Pedestrians, street-crossing, virtual reality, perception-action, biological motion

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1 INTRODUCTION

When immersed in a virtual environment, a user's primary characteristic is their interaction with that environment. This includes interacting with static elements of the scenery and, more importantly, with other people (virtual agents) who may be moving around using various modes of locomotion, such as walking, biking, or driving. The careful design of populated virtual environments that consider the interactions between different users and agents is crucial. This is essential not only for ensuring an immersive, realistic experience to the user but also, from the researcher point of view for creating immersive platforms that are relevant for studying human behaviour.

In the project PERCEPT-PIETON, we are interested in the interactions between pedestrians and vehicle, from the driver perspective. For a long time, safety policies have treated the pedestrian as a "moving obstacle in the path of vehicles". Today, however, walking is considered as a real mode of transport with its own travel

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constraints and objectives [Muhirad 2008]. In this respect, it is important to remind that pedestrians are variable, sensitive to their environment, sometimes inattentive (e.g. mobile phone) or hesitant, that their choices are often guided by route optimization objectives and for these reasons they can ignore signals and take more direct routes [Fitzpatrick et al. 2015]. It is therefore of main interest to understand these specificities when interacting with other users, especially when crossing the street.

Curiously, no study has focused on understanding and measuring driver dynamic behaviour when confronted with a pedestrian about to cross the street, specifically on the effect of pedestrian dynamic behaviour and locomotor pattern. Conversely, pedestrians-drivers interaction in road crossing tasks has been largely studied from the pedestrian's point of view [Dommes et al. 2021; O'Neal et al. 2018]. Other studies have focused on drivers' [Louveton et al. 2018] or cyclists' [Plumert et al. 2004] behaviour while they interact with others road users but still not during interactions with pedestrians.

One of the reasons why road user behaviour when facing a pedestrian has not been studied is probably technological [Day et al. 2019]. Pedestrian simulation models presented in 3D environments are sometimes far from the behaviours and motor signatures that can be observed in natural environments. In most cases, pedestrians are represented by virtual agents whose movements are based on models of locomotor patterns. In PERCEPT-PIETON, on the other hand, we will confront road users with virtual agents whose animation is based on previously captured motion and thus represents biologically plausible movements.

2 OBJECTIVES

The objectives of the PERCEPT-PIETON project are threefold: (i) to bring theoretical scientific contributions to the literature on obstacle avoidance and biological motion perception; (ii) to produce useful and operational knowledge for public policy makers by improving scientific knowledge on pedestrian safety, focusing on the way drivers perceive pedestrians' intentions and crossing behaviour; (iii) to create a library of biological pedestrian movements that will be freely available to the community for awareness raising, scientific experimentation or exploitation.

3 DESIGN AND IMPLEMENTATION

To achieve these objectives, we plan to immerse participants in a driving scenario in a virtual environment in which they will face digital twins of pedestrians presenting biological motion characteristics taken directly from motion capture - i.e. the reproduction of the motion performed by real pedestrians, as opposed to virtual agents walking around according to a model of locomotor patterns. While the drivers are confronted with different types of pedestrians (e.g. age, gender, etc.) with different behaviours (e.g. attentive or not, hesitant or not) and with more or less locomotor abilities, their behaviour will be recorded. Several experiments will be conducted using virtual reality headsets. They will drive through a virtual urban environment, more or less rich in visual information, until the appearance of a pedestrian about to cross the road.

Two types of task are tested to measure decision making and regulation of driver behaviour. In the first situation, the scene will freeze and the participant will be asked to indicate whether they

would have had time to pass by avoiding the collision with the virtual pedestrian (decision task). In the second task, while driving, the participant will have the opportunity to adjust their speed, direction or both at times in order to pass before or after the pedestrian (behaviour regulation task). At the same time, the headsets used will allow us to measure the participants' eye movements in order to inform us about their visual information gathering strategy.

In particular, we will look at the effect of individual pedestrian characteristics, such as age or gender; the effect of the level of attention that the pedestrian pays to the road and to the approaching driver, for example whether there is behavioural coupling or communication (formal or not) between these two users [Sucha 2014]; and the effect of pedestrian hesitation when approaching the road on driver behaviour [Jay et al. 2020].

We will focus on other factors identified in theoretical studies as important in the perception of moving objects [Casanova et al. 2022] or in the perception of biological motion [Hülemeier and Lappe 2020; Mayer et al. 2019] during the observer's self-motion. The speed, the angle of approach and the moment of appearance of the pedestrians will be variables to which we will pay particular attention. As has been shown for interception tasks, we hypothesise that these three parameters lead to changes in drivers' behaviour, and in particular influence their decision making, the way they gather visual information, or the way they regulate their approach speed and direction.

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