# IFSTTAR Street-Crossing Simulator: Technical Overview and Applications in Road Safety Research

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## Introduction

Pedestrians are known to be very vulnerable road users. Since the 70ties, road safety scientists have been interested in investigating pedestrian behaviour (especially of children and older people who are at the greatest risk), but were long time limited to accident and observational studies. Experimental studies in real world conditions were complex [Lee84, Dem92], while laboratory experiments used simplified video settings (e.g., [Oxl05]) that did not insure either interactivity or perception-action coupling.

Whereas driving simulators have been for decades a valuable tool for investigations of human behaviour and validation of advanced driver assistance systems (ADAS), the development of pedestrian simulators is still in the early stages. Thanks to the development of Virtual Reality (VR) technology, interactive street-crossing simulation devices have come into use in the early 2000s. This kind of devices enables studies on pedestrian behaviour in hazardous traffic situations (e.g. crossing scenarios) by offering pedestrian-vehicle interactions and the precise control of a large range of infrastructure configurations, speeds, gaps and types of approaching vehicles, as well as illumination conditions.

## The IFSTTAR street-crossing simulator

IFSTTAR developed in 2010 a CAVE-like immersive, interactive street-crossing simulator for its road safety research.

### Locomotion interface: the real walk

Walking in virtual environments is usually simulated though sliding shoes, treadmill (walking-in-place) or joystick. However, movements provided from those interfaces are still unnatural and the artificial coupling between visual flow and those movements

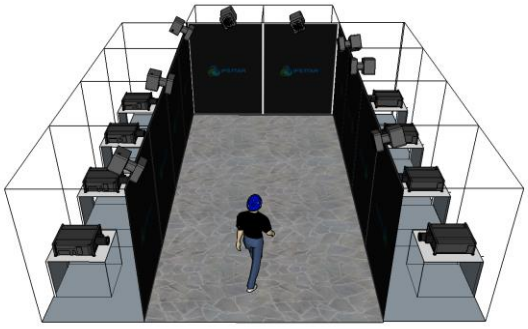

**Figure 1. The IFSTTAR street-crossing simulator**

is among the main sources of motion sickness. Besides, adapting to those movements requires some learning effort from the users. Developing a locomotion interface being able to support natural walks is still an active R&D topic of VR community. Since older pedestrians are one of the main targets of our research, the real walk was chosen to minimize their learning effort and to provide them with a high fidelity street-crossing environment.

The simulator, composed of ten 2.44 m X 1.83 m rear projection screens (four on each side, two in the front), is arranged to create a portion of up to 8 m wide experimental street on which the participants can actually walk (cf. Figure 1). The images projected on each screen are rendered thanks to PCs with dedicated graphics card.

### Large field of regard

The projection system provides the pedestrian with a horizontal field of regard (FOR) of between 180° (at the entrance of the simulator) and 300° (on the other end), and a vertical FOR of 40°. The images (60 frames per second), calculated and projected at each participant's eye height, are updated following the participant's position.

## Audio system

A spatial sound system is provided to the simulator thanks to speakers placed behind projection screens. The system can provide the directional sound from moving vehicles and the ambiance sound.

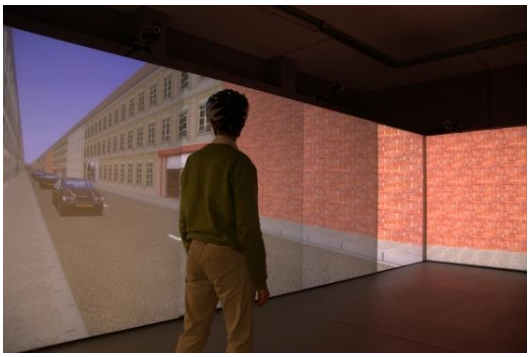

**Figure 2. A street-crossing situation**

## Motion capture

Scenes are updated interactively by a VICON® motion capture system that records the user movements with high precision thanks to reflective markers placed on the head and/or on the foot of each user. The system is composed of 8 cameras mounted on top of different projection screens to cover the whole walking zone.

## Simulation core software

The whole system is operated by IFSTTAR's own software (Sim2 and Dr2). Dr2 is the core of the simulation which provides the 2D top-view of the simulated road network and traffic vehicles and manages the communication with the VICON® cameras. Sim2 provides a visualization tool of the 3D environment corresponding to the road network controlled by DR2. The simulation is accomplished through TCP/IP communication between Dr2 and Sim2. Dr2 sends to Sim2 in real-time the traffic information specified in experimental scenarios and the user's spatial position and orientation so that Sim2 updates the user's viewpoint.

## Scenario control and Data collection

Scenarios can be created though a scripting language, interpreted by Dr2. This language is targeted for users with no programming experience. Subjects' behaviour (traffic observation, walking speed, walking pattern, etc.) can be studied thanks to the recorded data on the position and orientation of subject's head and foot. Behaviour of different traffic vehicles (position, speed) can also be controlled and recorded.

# Applications

The IFSTTAR street-crossing simulator has mainly been used for experiments on older pedestrians using a gap-acceptance paradigm. Two main kinds of study have been conducted so far. The first one has focused on older pedestrians' behaviour to better understand the underlying psychological determinants and to identify risk factors in a street-crossing task [Dom14, Dom15]. The second one has aimed at training older at-risk pedestrians to adopt safer crossing behaviours [Dom12]. Recently, the simulator has also been involved in an investigation on the efficiency of a vibrotactile navigation system to support old pedestrians to find their way in a city [Coe15] and on another one to understand the influence of another person on pedestrian street-crossing behaviour. In those studies, the visual scenes for a street-crossing situation typically represent a two-way street of 5.70 meters in width from pavement to pavement (cf. Figure 2). The traffic is generated on the near lane and/or on the far lane, the subjects have to decide whether or not to cross the street.

# Conclusion

The real walk capacity is one of the main advantages of the IFSTTAR street-crossing simulator. Thanks to this particular feature, the street-crossing task is easy to understand for both young and old pedestrians. It is important to note that no simulator sickness has been observed during all experiments in aforementioned studies. With a real street-crossing action and without simulator sickness, the simulated condition provided by the IFSTTAR street-crossing simulator is very close to the real condition. In addition to the street-crossing scenario, the large working space provided by the simulator could also support other types of scenarios such as those focusing on the safety of road workers on highway, for example. Last but not least, understanding the different factors that contribute to the validity of the IFSTTAR street-crossing simulator has been and will be among the main research focuses on this device in upcoming years.

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