AN EXPERIMENTAL PROTOCOL TO STUDY THE CAR INGRESS/EGRESS MOVEMENT FOR ELDERLY AND PATHOLOGICAL POPULATION

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Abstract

The increasing presence of elderly and pathological populations in our modern societies made it necessary to improve the usability of many products. One of the key issues concerning vehicles is ease of ingress and egress movements. However, few studies are devoted to this problem. The objective of the present paper is to expose the experimental protocol of the HANDIMAN project lead for this purpose. A mixed population of forty one test subjects took part in the experiments. Kinematic and dynamic data are recorded. First results showed many differences between the subjects according to their state.

Keywords: Automobile ingress/egress movement, elderly and pathological population, experimental protocol, Biomechanics, handicap.

1 Introduction

The Metropolitan France will count from 58 to 70 million inhabitants in 2050 year (Brutel 2002). In this horizon, more of the third of the population will be old of more than 60 years, against one fifth in 2000 year. This ageing of the population is general with all the industrialized countries and will be accompanied by a growth of the number of handicapped people (e.g. physical handicapped persons). The number of old and handicapped drivers will thus irremediably increase. The car manufacturers are conscious of this fact and are interested more and more in this growing old and subjected to handicaps population. Vehicle ingress/ egress movement is a complex action requiring a precise articular movement coordination of the human body (Gransitzki 1994). This banal movement, even automatic, is for the older population one difficult motor act which can force them to stop driving (Cappelaere et al. 1991).

To try to satisfy these customers, the manufacturers should ask on old subjects and/or pathologic persons to carry out ingress/egress movements on prototypes or mock-ups of real scale. The subjective judgement given by these people taking part in the experiments is then correlated with dimensions of the vehicle (Sternini and Cerrone 1995). The construction of this (ese) nonreusable prototype(s), the number of subjects and the analysis of the data generate significant costs. Moreover, the corrections on the prototype are not always possible (Verriest 2000). HANDIMAN project aims at integrating this phase of discomfort evaluation in the first stages of the design for this type of population. The HANDIMAN is a three-dimensional "Handicapped" virtual man able on the one hand, to enter/leave a motor vehicle and on the other hand, to specify the obstruct felt at the time of the realization of its movement. Feedback must allow the optimization of dimensions of the vehicle in agreement with driving deficiency considered.

This project concerns 2 scientific problems: the simulation of the complex realistic movements and the evaluation of its discomfort which both do not find yet a solution in the use of the virtual manikins present on the market (Chaffin 2001, Dufour and Wang 2005). The step implemented by HANDIMAN consortium aims in a first stage to better knowing this movement and the behaviour of this population in the realization of this task. This knowledge is acquired by the experimentation on the human being.

The objective of this paper is to present, in a synthetic way, the protocol and the experimental device set up at the LAMIH (University of Valenciennes, France). First results, directly resulting from measurements, are presented to illustrate this first work.

2 Methods

2.1 Experimental device

The experimental device is mainly composed of:

- Four stripped vehicles (RENAULT Kangoo, RENAULT Mégane, PEUGEOT 806 and FORD Fiesta) in order to limit the screening of the markers set on the subject (fig. 1).
- Three dimensional optoelectronic motion capture system VICON ® 612 provided with 8 CCD cameras of sampling rate of 60 Hz surrounding the studied vehicles.
- Two Kistler® force plates laid out on the ground and solicited by the subject before entering the studied vehicle.
- Logabex® force plate laid out in the floor of RENAULT Kangoo and solicited by the subject at the time of the entry in the cockpit.
- A grid of calibration, fixed at the ceiling temporarily, used to determine the anthropometry of the test subjects.
- A VHS recorder to record the subjects' ingress/egress movements (on their vehicle and in the experimentation) to constitute a base of movement specific to the population.
- A subjective questionnaire, proposed to the test subjects before and after each passage on each vehicle, aiming to account the obstruct felt of accessibility to the tested vehicles.

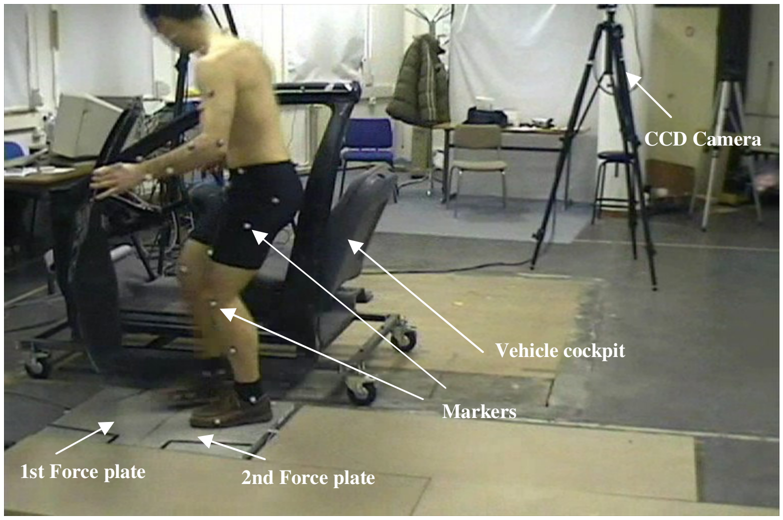

Figure.1. *Experimental workspace.*

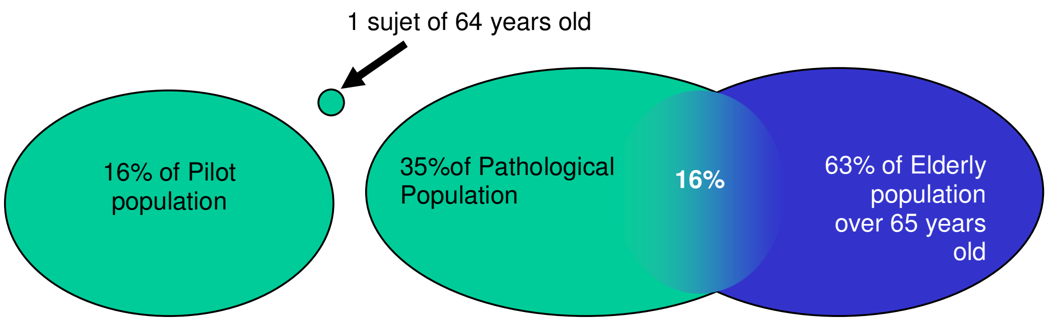

Figure.2. *Test subjects population partitioning.*

Stages	Description	Objective	Duration
Stage 1	Markers positioning on the subjects	3D movement of the different body segments reconstruction and the stick figures building	20 mn
Stage 2	Anthropometric measurements	Subjects' anthropometric dimensions characterisation	10 mn
Stage 3	Taking photos inside of the calibration grid	Calibration of the numerical manikin with the subject's dimensions (Sietz and Bubb. 2001)	5 mn
Stage 4	Test of the articulation limits	Characterisation of the subject articulations' limits	10 mn
Stage 5	Arms and legs rotations	Shoulders and hips articulation centers determination	5 mn
Stage 6	Vehicle Ingress/ Egress movements	Ingress/egress movements measuring and recording	50 mn

Table.1. *Experiments' stages description.*

2.2 Population

Forty one test subjects took part in the experiments (27 males and 14 females). The subjects of the experiments are primarily issued from an old driving population of over than 65 years and a pathologic population with prosthesis of hip or knee (right-hand side or left) driving as well. Among the forty one subjects there were seven healthy subjects taken as pilot population. The twenty six elderly subjects contain seven subjects having prosthesis of the hip or the knee (right-hand side or left). The eight other subjects having prosthesis are young. The test subject population partitioning is summarized in figure 2.

2.3 Experimental protocol

The experiments aimed to determine the kinematic and dynamic characteristics of the subjects' movements. The experiments proceed in several stages over an average duration of two hours per subject. The different stages occur in a chronological order. The different stages of the experiment are summarized in table 1.

3 First results

The participation of a large and variable population in the experiments allowed us to obtain a wide data base of movements. The kinematic and dynamic data obtained showed many differences between the subjects while entering and exiting the vehicles.
For an illustration purpose only ingress movements will be presented and only the external force according to the Z axis will be shown. The ingress movement kinematic and dynamic characteristics of three randomly chosen subjects will be presented.
The ingress movements are realised on the FORD Fiesta vehicle. Each ingress movement is partitioned into three phases:

- Door opening phase: This phase begins when the subjects set their hands on the door handle and ends once the door in totally opened so that to permit the ingress in the vehicle.
- Ingress movement adaptation phase: This phase begins once the door is opened and ends with the takeoff of the left leg from the ground into the vehicle floor.
- Positioning on the seat phase: This phase begins with the takeoff of the left leg and ends once both legs are inside the vehicle floor and they are immobile.

In the following the ingress movements stick figures and external force according to the force plates Z axis of the three subjects will be presented.

• **Healthy subject (fig. 3)**

Door opening phase (A)

The healthy subject took less time in this phase (less than one second). He performed this phase outside of the force plates thus we don't notice the presence of the signal in the force plates.

Ingress movement adaptation phase (B)

During this phase the subject set his left leg (laying leg) on the ground (force plates) while he drew his right leg (attack leg) directly inside the vehicle floor. He bent his torso and his head so that to avoid the collision with vehicle's gauge. The subject set his laying leg between the two force plates. From the dynamic curve we can notice that in the beginning of the movement the subject applied an important laying on the second force plate, then gradually he slided around his laying leg so that to adopt an adequate ingress position. The position adaptation caused a gradual force transfer on the first plate. However, there still an alternating of the force repartition between the two plates until the end of this phase.

Positioning on the seat phase (C)

During this phase the subject set definitely his legs inside the vehicle floor, his hands on the steering wheel and he is ready to drive.

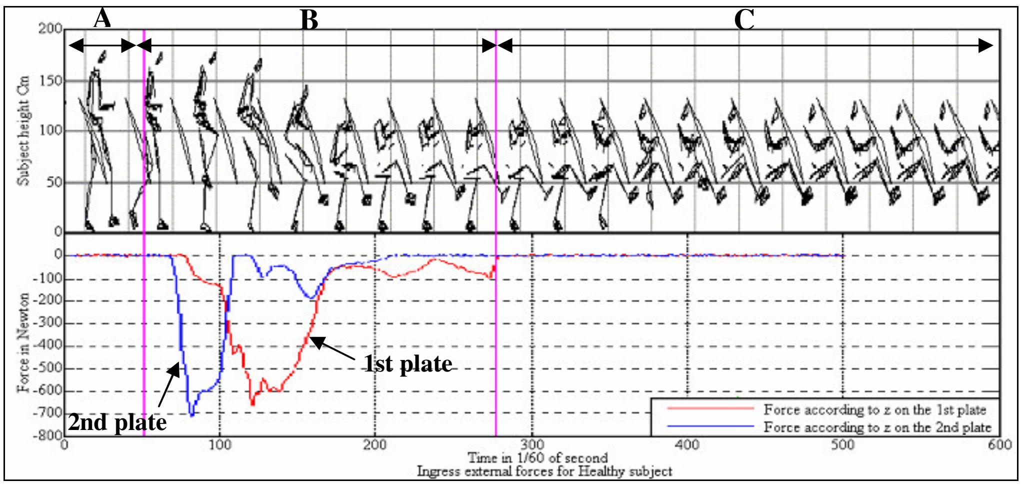

Figure.3. *Healthy subject ingress movement stick figure and external force according to the laboratory Z axis (19 years old, 194 cm height, 70 kg weight, no health problems).*

• **Pathologic subject (fig. 4)**

Door opening phase (A)

In this phase the pathologic subject drew near to the vehicle to open its door, thus he set a part of his right foot on the second plate, for this reason we notice a presence of a dynamic signal on the second plate. The signal's amplitude does not reach its maximum value.

Ingress movement adaptation phase (B)

During this phase the subject performed series of movements to adopt his own strategy. From the dynamic curve we can notice the gradual masse transfer between the two plates. Indeed, in his strategy, the subject sets his buttocks on the seat first, then he moves his legs alternatively so that to get an adequate position that will facilitate the next phase. By the end of this phase we notice a decreasing of the dynamic signal amplitude due to the transfer of a part of a force on the vehicle's seat.

Positioning on the seat phase (C)
During this phase the subject set definitely his legs inside the vehicle floor, his hands on the steering wheel and he is ready to drive.

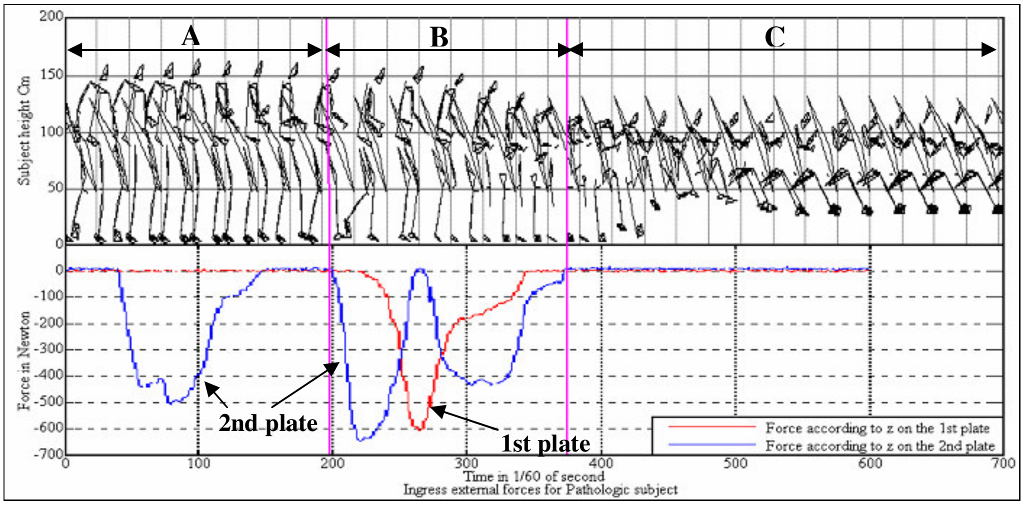

Figure.4. *Pathologic subject ingress movement stick figure and external force according to the laboratory Z axis (53 years old, 172 cm height, 67,4 kg weight, right hip prosthesis).*

• **Elderly pathologic subject (fig. 5)**

Door opening phase (A)
During this phase the elderly subject performed the same movements as the young subject. Indeed, they adopted same strategy.

Ingress movement adaptation phase (B)
During this phase the elderly subject seems to adopte the same strategy than the young subject, thus he did same movements. The dynamic curves have same pace. However, the elderly subject set his laying leg just on the second plate and he took much more time.

Positioning on the seat phase (C)
During this phase the elderly subject performed also same movements than the young subject.

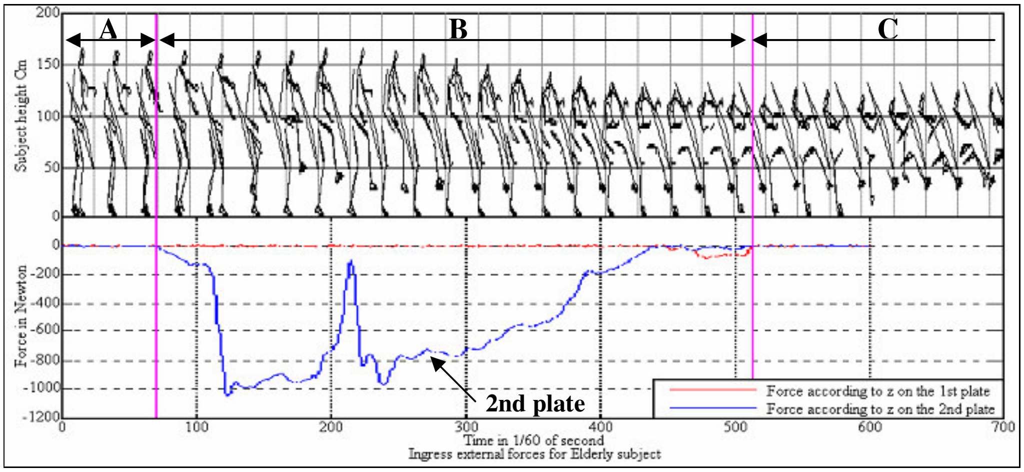

Figure.5. *Elderly pathologic subject ingress movement stick figure and external force according to the laboratory Z axis (84 years old, 172 cm height, 102 kg weight, left knee prosthesis).*

4 Conclusion and future work

An experimental protocol and device were set up to satisfy HANDIMAN project. This protocol allows the measurement of kinematic, dynamic and video data of the ingress/egress movements of elderly and pathologic population. The first results show a diversity of the strategies which appear so much by kinematics than by the developed external efforts. These results are original and for this reason they constitute a significant base of knowledge on the accessibility movement for this type of population.

The following stage will aim at the reconstruction of the ingress/ egress movement so as to reach the articular angles. The coupling of these data, anthropometry and the external measured data will allow, by using inverse dynamics, to calculate the efforts generated on the level of the articulations.

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