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Perceived quality of interior automotive components

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INTRODUCTION

The automotive sector has very strict quality standards and a final client with very high expectations. Vehicle manufacturers (OEM) currently delegate the responsibility of proposing technical, and sometimes aesthetic solutions, to their direct suppliers (TIER1). Nevertheless, these aesthetic solutions must be discussed (and often justified) with the client, thus warranting the development of prototypes to be evaluated by the final client’s target users.

This responsibility involves studying the perception of quality, analysing the overall impression of the client – the vehicle customer – through their different senses, and to progress towards evaluation methods that reduce high prototyping costs.

With regard to the former, the interaction between people and products is a complex phenomenon, and is the result of the interpretation processes associated with different sensory stimuli. This interpretation leads the users to be satisfied or dissatisfied through perceived quality, consequently generating different emotional states.

Perceived quality is defined as the result of the cognitive and emotional comparison of the client’s expectations of a product and the results actually delivered by the product’s features in a specific use.

Thus, the use of suitable methodologies facilitates, on the one hand, capturing sensory wealth generated by a product in users through the stimulated senses and, on the other, characterising a product’s properties on the basis of the ensemble of sensory stimuli, increasing the perception of quality in the target users, a key factor in product success.

Regarding the second aspect, in recent years different product assessment methodologies have been defined and fine-tuned in which information is usually presented to the consumers using actual products. Although these methodologies were initially conceived to assess manufactured products, company needs (reduction in prototype manufacturing costs and time, resource optimisation) have led these product assessment methodologies to be adapted to visual representations: an image, a CAD model or even virtual reality techniques. This allows the evaluation of products without the need for a physical prototype.

The Biomechanics Institute of Valencia (IBV) and FAURECIA Interior Systems worked together to develop a virtual evaluation protocol of perceived quality of interior automotive components. To this end, the differences between the evaluation of the real product and a rendered...
image were analysed. The types of adaptations required were identified in the perceived quality evaluation protocols on real parts to obtain a duly validated virtual evaluation protocol.

Development

The plan of work carried out during the project, a joint effort with the FAURECIA company, is shown in figure 1. The plan divided the experimental phase into two parts. An initial exploratory phase in which the actual users evaluate the real and virtual prototype, allowing the detection of differences and aspects of the product that could be improved and better adjusted. The second phase validated the redesigned protocol with two user groups that rated real and virtual prototypes, respectively.

Task 1. Revision of protocols for the design of a virtual evaluation protocol

Although theoretical approaches to perceived quality already exist in the automotive sector and there are even some dealing with specific parts or components, it is difficult to find specific protocols that can evaluate the characteristics of components related to perceived quality of finish.

In this task, existing quality inspection plans for the design of a virtual evaluation protocol were analysed. The media used to collect the information were based on a bibliographic review, through a panel of experts with personnel from the quality department of the FAURECIA company.

As a result, a proposal of a virtual evaluation protocol of perceived quality was generated, identifying the most relevant aspects for the user being evaluated and adapting both the language used in the questionnaire and the protocol's complexity and duration.

Task 2. Image/prototype generation

One of the key aspects for a successful virtual evaluation is the generation of the rendered images and the presentation of the stimulus. Details such as lighting, colours, textures, user point of view, etc., must be well defined to avoid discrepancies in the perception between the finish of the actual prototype and its rendering.

Six door panel prototypes were manufactured for the experiment. Different panel elements were modified (insert, top roll, grilles, geometry, finishes and materials) and their corresponding renders were generated.

Task 3. Eye-tracking: analysis of the visual inspection process of the interior design of a door panel

This task allowed analysis of the differences between the way a product is explored visually and its virtual representation, identifying observation patterns and variability between the types of representation (real and image) (Figure 4). The panel was divided into 11 areas of interest depending on the design

Figure 1. Plan of work.

Figure 2. Rendered image of a vehicle door panel.
variations (Figure 5) so as to be able to study exploration patterns while the users rate the door panel range.

As a result, no differences were appreciated between the number of gazes (when the user dwells on a point) or their duration between the actual representation and the image (Figure 6). Thus, the order in which the elements of the real door panel and the image are tracked by the eye are very similar.

**Task 4. Exploratory experimentation**

This experimentation featured the participation of 8 users in four stages. In the first two stages, all the users rated both representations (real and virtual) of the same door panel, with the order changed, whereas in stages 3 and 4 the users evaluated both representations of another door panel model. In each stage, the user described the door panel in their own words (overall and in terms of quality) and completed the questionnaire generated in task 1.

This task demonstrated that the complexity of the task was suitable for the users and that the users did not raise any other kind of attributes or characteristics of the door panel that had not already been provided for in the questionnaire. The effects of the differences between the real and the virtual representation and the type of additional information and adjustments required by the virtual evaluation were also observed.
Task 5. Validation

This task entailed the validation of the virtual evaluation protocol (Figure 7). Twenty-four (24) users participated; half of them performed the evaluation using 6 real prototypes while the other half used the images.

As a result, the consistency of the information collected was verified, the shortcomings of the virtual protocol were identified and recommendations to guarantee its validity were generated. The sample size needed in order to obtain a reliable response was also calculated.

Conclusions

The use of images instead of physical prototypes makes it much easier to make changes (geometry, textures, finishes, design) rapidly, even addressing options that would be difficult to implement in physical prototypes.

Herein lies the interest in generating a “virtual evaluation protocol”: guaranteeing assessment of a product in the design phases to facilitate the implementation of recommendations in order to guarantee a successful finished product, all while optimising company resources and saving costs.

Nevertheless, the development of a virtual evaluation protocol of perceived quality has its limitations, and attention must be paid to a wide number of details to reduce discrepancies when performing the evaluation based on a real product or a representation (render).

The way the stimulus is presented and the realism of the render all have a major influence on the outcome of the assessments. Lighting conditions, colour contrasts, part finish, reflections and light halos, etc., must all be controlled. This work is ongoing and opens up the way for significant cost with outcomes that are valid for the client (OEM).

Figure 7. Evaluation protocol stages.

<table>
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<tr>
<th>USER SELECTION</th>
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<th>PRESENTATION OF THE STIMULUS</th>
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In this project the company enjoyed the support of the Centre for Industrial Technological Development (CDTI) through its Programme for Research and Development Projects (RDP).
Comfort on trams

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INTRODUCTION

In recent years, the tram has consolidated its position as one of the most popular means of transport in metropolitan areas, with a major growth in lines and users. According to data from the Ferrocarrils de la Generalitat Valenciana (FGV) there were more than eight million tram users in Valencia alone in 2011.

In view of this growing demand, travellers' expectations are becoming increasingly more important in promoting the use of this means of transport. Vossloh, a worldwide reference manufacturer of railway vehicles, and as a new tram manufacturer, considers travellers' opinions a key aspect that must be addressed in the vehicle design phase.

Hence, the project conducted in conjunction with the Biomechanics Institute seeks to ascertain user opinions about this type of vehicle as well as identifying and evaluating the main design factors that affect user-perceived comfort.

METHODOLOGY

The study consisted of the following phases:

PHASE 1. Validation of comfort factors
PHASE 2. Questionnaire design
PHASE 3. On-board surveys
PHASE 4. Analysis of the questionnaires

In the railway sector, one of the key aspects in the vehicle design phase is passenger comfort, hence passengers' opinions should be taken into account.

The Biomechanics Institute of Valencia (IBV), at the request of Vossloh, carried out a study to ascertain the main factors that influence on-board comfort in tram users.

Phase 1. Validation of comfort factors

The first phase consisted in identifying the main factors impacting traveller comfort. UOI (user oriented innovation) methodologies, based on the direct participation of representative samples of end users, were used to conduct interviews and discussion groups with regular tram users.
According to the travellers, the main factors that affect comfort on the tram are:

- Acoustic comfort
- Thermal comfort
- Dynamic comfort
- Visual comfort
- Postural comfort
- Vehicle accessibility

Subsequently, meetings were held with Vossloh’s experts to determine the tram design aspects that are associated with the comfort factors identified by travellers.

**Phase 2. Questionnaire design**

A questionnaire was designed using UOI methodologies to collect traveller opinions. The questionnaire comprises the following sections:

- Characterisation of the use of the tram. Some of the variables obtained are: reason for use (work, studies, different kinds of journeys), frequency of use by the traveller as well as origin and destination of the current journey.
- Traveller’s assessment of on-board comfort. The following aspects were assessed:
  - Overall satisfaction with comfort on the tram.
  - Factors with the greatest influence on overall perception of comfort on the tram and the assessment of these factors.
  - Tram design elements related to comfort factors.
- Traveller characterisation. Compilation of the socio-demographic characteristics of the traveller interviewed.

**Phase 3. On-board surveys**

The field work consisted in on-tram interviews with travellers. The interviews were conducted on the tram lines of the city of Valencia (line 4) and Alicante (lines 1 and 3), where there are two kinds of trams as well as a train-tram.

The study includes the ratings of 198 frequent tram users, 50% men and 50% women, of different age groups.

The sample guaranteed variety in terms of type of vehicle, section of the route, the tram area where users travel, and whether they are sitting or standing.

**Phase 4. Analysis of the questionnaires**

The information collected in the field study was analysed in detail in order to determine the influence of comfort factors on the overall on-board comfort rating.

**RESULTS**

On the basis of the survey it may be concluded that travellers place great value on overall on-board comfort.

Similarly, according to travellers, the most important factors affecting the tram’s overall rating are sound, access, vehicle movement and the traveller’s posture or stance during the journey.

**CONCLUSIONS**

The study allowed the characterisation of overall traveller comfort through an analysis of users’ responses. This was done by identifying factors that influence the perception of comfort on the tram and its main design-related aspects.

These results can be used by Vossloh to steer its innovation strategy in the design of vehicles in the future to guarantee traveller satisfaction on its trams.

**Acknowledgements**

We would like to thank the FGV for giving us permission to conduct the questionnaires on the tram and train-tram lines in the cities of Valencia and Alicante.
Biomechanical analysis of the new The North Face running footwear

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INTRODUCTION

Regularly doing sport improves health and is conducive to physical and psychological well-being. Controlled and scheduled sport is key to a good quality of life. One of the most popular sports in recent years is running. Footwear is one of the basic items required for running. Runners are becoming increasingly more demanding, calling for more technical products to improve performance while preventing injury. Sports footwear manufacturers are well aware of these demands and are investing greater resources to cater to user demands.

Users need objective information on the true properties of shoe models. Moreover, manufacturers are obliged to provide objective proof of the quality of their products. IBV offers sports footwear assessments to help manufacturers develop their products and objectively evaluate the functionality of their footwear models. By way of example, this article expounds the work conducted in conjunction with The North Face.

DEVELOPMENT

The objective of this study was to analyse the biomechanical behaviour of different models of running shoes made by The North Face. The study involved the following:

-- A biomechanical analysis.
-- A runner perception study.
-- An assessment with mechanical tests.

Fifteen (15) regular runners with the same shoe size were selected to perform the biomechanical assessment and the perception study (Figure 1). The participants were recruited during the 31st Divina Pastora Marathon of Valencia, with the invaluable collaboration of the Sociedad Deportiva Correcaminos. In order to guarantee runner suitability, an expert chiropodist performed an evaluation of the lower extremity at the IBV before the biomechanical analysis. The clinical assessment consisted in a static and dynamic evaluation of the lower extremity, analysing the morphology and functionality of the legs, ankles and feet (Figure 2).

The biomechanical analysis addressed basic aspects such as the footwear’s impact absorption capacity, movement control and flexibility. Different techniques were used for this purpose.

-- Reaction forces with the ground were recorded with the Dinascan/IBV® force platform. This equipment records the force generated on the ground during the step in the three axes (vertical, anteroposterior and mediolateral) of running. Particular attention was paid to the initial part of the curve, where it is possible to evaluate the impact...
The evaluation of the impact absorption level of the different shoes was complemented by fitting an accelerometer to the front of the leg and to the head at forehead level. This made it possible to study the transmission of the impacts taking place during the initial contact of the foot and the ground throughout the musculoskeletal chain.

Finally, the photogrammetry technique was used to complete the biomechanical assessment. This technique is based on the localisation of the coordinates of certain body points in space by using several synchronised cameras (Figure 4). The equipment used by the IBV is a Kinescan/IBV®, based on 12 high-speed cameras strategically placed to record human movement during running (Figure 5). Thanks to this technique, movement was recorded in the knee, ankle and metatarsophalangeal articulations in the vertical, anteroposterior and mediolateral axes. This information is crucial in providing an overall view of the effect caused by a given design of running shoe on the runner’s movement. Important aspects, such as the shoe’s level of flexibility or the adaptation of each shoe model to neutral, pronator or supinator runners can be determined with this technique (Figure 6).
Parallel to the biomechanical assessment, **perception tests** were performed to rate aspects such as comfort, stability, weight, flexibility, impact absorption capacity, fit between foot and shoe, movement control or thermal comfort.

Finally, **mechanical tests** were conducted to evaluate the impact absorption capacity of the various shoes and to compare the results to the ones obtained in the biomechanical analysis. This mechanical test was carried out with the

![Figure 5. Step movement sequence during the race.](image-url)
LecCus/IBV® machine which simulates the impact forces on the shoe during the initial contact between heel and shoe (Figure 7). This test determines important parameters such as dynamic rigidity or the shoe materials’ energy absorption and return capacity at each step.

The statistical treatment and evaluation of the tests’ results yielded a detailed assessment of the functional behaviour of each model.

**Conclusions**

Comfort, performance, flexibility, weight, stability, impact absorption, thermal comfort and movement control are functional aspects that are increasingly more appreciated and requested by ever-more demanding regular runners.

This collaboration project between the IBV and The North Face has allowed the evaluation of these functional aspects of running shoes as well as their comparison to runner perception.

The results allowed us to evaluate the company’s current running lines. The information obtained will be highly useful in the development of running shoes in the future.

**Acknowledgements**

- To The North Face.
- To the 31st Divina Pastora Marathon of Valencia.
- To the Club Deportivo Correcaminos.
ITURRI heatable garments for extreme cold conditions

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Biomechanics Institute of Valencia

Introduction

The INFINITEX project, which stands for Investigation of New Functionalities and Intelligence Implemented in textiles, is one of the CENIT (Consortios Estratégicos Nacionales de Investigación Técnica) projects funded by the Ministry of Science and Innovation through the Centre for Industrial Technological Development (CDTI).

The objective of the project is to create and promote a national value chain for working with functional textiles that have high added value. The ultimate goal is to increase their practical applications, protective features and comfort by acting in different phases of the production process and also with textiles used in different areas of activity such as defence, health, industry, emergency and transport (automotive).

The project partners include companies from different sectors (automotive, textile and technology) and of different sizes (from large corporate groups to SMEs).

The consortium, led by the Iturri Group, consists of 16 companies: Grupo Iturri, Antecuir, Anglés Textil, Grupo Antolín Ingeniería, Comersan, Sati Grupo Textil, Estambril, Francisco Albero, Industrial Química del Nalón, Manterol, Marina Textil, Selvafil, Sistemas y Procesos Avanzados, Textulan, YFlow, Sistemas y Desarrollos.

The project also calls for the collaboration of 10 technological centres and public research organisations: IBV, CETEMMSA, AITEX, CTME, FITEX, GAIKER, University of Barcelona, University of Burgos, University of Valencia and the University of Zaragoza.

CENIT INFINITEX is therefore a multidisciplinary, multisectoral and inter-regional project.

The project kicked off in 2009 and ran for 3 years. The Biomechanics Institute participated in different research objectives, such as: integration of sensors into fabrics; the integration of air conditioning and heating systems into fabrics; the development of fabrics that enhance the user’s thermal perception or the development of fabrics with microencapsulated active substances. IBV’s work consisted in generating specifications for textile development where special consideration was given to end-user needs; the assessment during prototype development, and validation of the developed prototypes.

As an example, of the work carried out in the development of the heating systems integrated in the textiles is presented below.

The Biomechanics Institute of Valencia (IBV) is participating in the CENIT INFINITEX project, coordinated by the ITURRI company, whose main objective is to develop a new generation of technical textiles, such as multifunctional textiles, which make it possible to integrate functionalities in a single textile; advanced textiles that offer high performance and specific technical characteristics, and intelligent textiles, capable of reacting to certain external stimuli.

IBV participated in the generation of specifications for the development of the different research lines, assessment in the development of the new technologies and the evaluation of the demonstrators of the technologies developed during the project.

This paper presents the work carried out by IBV for ITURRI for the development of heated garments.
> **Development**

One part of the assessment phase included the analysis of end-user needs. To this end, discussion groups were set up with different groups that tend to work in adverse weather conditions, such as military employees, firefighters, emergency service personnel or electricity company workers. These discussion groups revealed user needs related to the use of clothing in cold and extreme cold conditions. For example, information was collected on body parts most exposed to cold temperatures, the time exposed, cold exposure conditions, the most suitable garments, etc.

In order to define the specifications of the project demonstrators, a simulation was carried out using thermal models of the human body exposed to extreme cold (Figure 1), calculating the heating power required to achieve protection from freezing and hypothermia. The calculation of these simulations was based on the system proposed by the UNE EN-ISO 11079 standard: Ergonomics of the thermal environment. Determination and interpretation of cold stress when using required clothing insulation (IREQ) and local cooling effects. The equations were adapted to introduce the heat input of the garments in which the heating systems were to be included.

Simulations of different possible scenarios were performed in which environmental conditions, levels of metabolism and the clothing's thermal insulation were modified. These simulations yielded the heating powers required for each garment.

Figure 2 represents a simulation performed for heated gloves showing the need for additional heat depending on the glove's heat insulation and ambient temperature.

IBV used this information to generate the specifications for each of the demonstrators and assisted in their development.

To validate the garments, a test methodology was developed with people in conditions of use inside a climate chamber simulating cold and extreme cold condition, figures 4 and 5. At the beginning of the tests, users were instrumented with temperature sensors on the skin surface, as well as microclimate sensors (temperature and humidity) on different areas of the body, depending on the garment being evaluated: gloves, tee-shirts, trousers or boots.

The users entered the climate chamber and answered surveys related to temperature and comfort perception in the course of the test.

The objective temperature and microclimate information was processed statistically and compared to the data obtained from the surveys in order to analyse the performance of the garments worked and to generate recommendations for improvement.

The results obtained were the skin and microclimate temperature curves during the tests, as well as the users' perception of comfort and thermal sensation.

An increase in skin and microclimate temperature was observed while the garments were connected in cold environments (-10°C). User perception while the clothing was connected was one of comfort, whereas once the equipment was disconnected, the microclimate and skin temperature decreased.
was disconnected the users began to feel cold, eventually reaching uncomfortable levels.

These results demonstrate that heated clothing improves comfort in the body part to which heat is supplied as well as overall body comfort and heat sensation in cold and extreme cold conditions.

CONCLUSIONS

IBV participated in the INFINITEX project by providing the know-how and methodologies required to involve end users in the development of a new generation of technical textiles. In the example indicated in the article, heated fabrics, the combined use of techniques to identify the needs of the different groups of professionals, together with real-time experiments with users and the application of different extreme cold scenarios, proved to be highly useful for the application of new in-garment heating technologies to solve users’ problems.

The support of the demonstrators during the course of the project made it possible to determine the benefits of this type of clothing for users when exposed to extremely cold weather conditions.

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We would like to thank the ITURRI company for its efficacious leadership of the consortium which made it possible to bring this project to a successful conclusion.

The INFINITEX project is part of the CENIT (Consortios Estratégicos Nacionales de Investigación Técnica) projects approved by the Ministry of Science and Innovation through the Centre for Industrial Technological Development (CDTI).
Improving user balance with video games

In recent years, the computer and video games industry has created new home-based, low-cost technologies for capturing human movements which make the combination of video-games and biomechanical analysis a feasible reality. The iStoppFalls project leverages this opportunity to assess the risk of falling and to improve user balance during their interaction with exercise games. One of the challenges is to achieve measures of sufficient quality from a system originally designed for capturing gross movements. This problem is solved by a redefinition of the measurement protocols, plus an advanced analysis of the variables captured by the video game sensors, in order to reduce the gap between target and actual precision. Validated fall-risk assessment criteria have been adapted to exercises that can be performed at home without supervision or additional instrumentation. A skeleton model with 22 degrees of freedom was tracked by Kinect, with joint angles corrected by a particle filter.

INTRODUCTION

Falls are caused by many factors and may have numerous interlinked causes. Some are related to the environment or setting, such as the place where we live or our lifestyle, whereas others are individual factors related to health and physical fitness: previous falls, gender, age, medications taken, mental health or physiological aspects.

Of these causes, physiological factors are of particular interest since they can be measured by our body’s response to specific tests. One traditional approach to fall-risk assessment is the evaluation of postural control while the person is standing, using simple human body models such as the “inverted pendulum”: a rigid bar fixed to the floor by a spring which causes it to swing, with its centre of gravity moving with a dynamic that depends on posture control. There are also more complex approaches that measure the body’s reaction in other tasks, related to the more usual occasions when there is a risk of falling, such as: the act of sitting down and standing up, walking, stooping, etc., in which body models with kinematic chains are used.

In some cases, whole-body models are used and supported by data on masses and moments of inertia of different body segments. These can be used to measure body dynamics in any type of movement and evaluate ranges of movement and other kinematic variables that may be of interest. This approach is particularly useful when applied to modern fall-risk techniques, based on validated risk factors and capable of discriminating between people with different tendencies to fall. These methods usually function using information on the person and their setting as well as the results of certain physical tests, such as reaction times in the event of a stimulus, putting one foot forward, going up stairs, sitting down and standing up, lifting one’s legs while seated, etc. These techniques are not based so much on exact measurements of the displacement of a person’s centre of gravity but rather on a series of parameters that are easier to measure and selected specifically because of their high sensitivity and specificity in predicting the risk of a fall.

These measurements are particularly suitable for being taken with low-cost devices such as the ones used in the new personal consumption technologies such as video game consoles. This also coincides with the current tendency to integrate healthcare and quality of life within leisure using new technologies. This is the underpinning principle of the iStoppFalls project funded by the 7th European Union Framework Programme and coordinated by the University of Siegen (Germany), with the participation of technological centres and companies from four European countries, including the Biomechanics Institute of Valencia.
(IBV) and the Neuroscience Research Australia group, a worldwide leader in the study of falls.

**Development**

The objective of this project is to develop a system based on information technologies to help prevent falls in the elderly through educational contents and exercise programmes which will be used to evaluate and train their balance. The system will be managed by an information and knowledge social network that the user will be able to access through their television and a video game console (Figure 1). The main video game console is the Microsoft Kinect sensor, used to interact through gestures and to monitor movements during the games and exercises. Some exercises (the "bubble bursting" game, plus postural and sitting down and standing up activities) are adaptations of validated methods for evaluating the risk of a fall. Others, such as the "Otago" exercise programme and balancing video games (Figure 2) are used to exercise user strength and balance using personalised training programmes. The system also provides the user with a social network and training contents to improve their health and physical condition.

The movement analysis used to evaluate balance and level of completion of the exercises is based on a skeleton model, with 15 characteristic points of anatomy and 10 articulations between segments. This model may be obtained using the analysis of the information provided by the Kinect’s optical sensor, although a major problem of precision of the biomechanical variables had to be overcome first (Figure 3).

The sensor in question and the associated software have not been designed for research applications requiring a high quality of results, but rather to control video games, normally based on monitoring the position of the anatomical points (particularly hands and feet) in two dimensions. However, biomechanical analysis requires a reliable measurement of articular angles (rotation of shoulders, elbows, hips, and knees).
knees...) which the Kinect development kits do not provide to an adequate level of quality. Although the articular angles required for the analysis are directly related to the positions of the anatomical points that the sensor detects reasonably well, the number of these points is well below the number required by conventional reverse kinematic analysis procedures, which leads the estimations of angles obtained from the sensor to be unstable and incorrect.

For the biomechanical analysis, even at the simplest level required by the modern fall-risk evaluation techniques, suitable articular angle measurements must fulfill the following conditions:

- Be consistent with the positions of the anatomical points considered by the biomechanical model.
- Be physiologically acceptable (the postures analysed must be within the articular ranges common to the population).
- Have a smooth evolution that makes it possible to draw conclusions on the dynamic aspects of posture as well as producing an acceptable animation of the avatar during video game sessions.

To achieve these results, the IBV uses a method of calculation of the articular angles based on the "particle filter" technique, based on a kinematic model with 22 degrees of freedom (three per articulation, excluding elbows and knees, which were modelled with a single degree of freedom). This is a statistical method for solving data merge problems when you work with the dynamic model of a physical phenomenon plus another source of information on variables of interest (in this case the articular angles).

The dynamic model used for this problem was a "Brownian" model in which the evolution of articular angles is random, but smooth movement is guaranteed within defined limits (the mobility ranges of each one of the articulations). With this model, every instant a simulation calculates more than five hundred possible postures based on the posture detected in the preceding instant. All these possible postures are filtered according to the observed positions of the anatomical points, and the one that is most consistent with a defined kinematic model is selected.

To fine-tune this technique, lab tests were conducted in which the subjects performed 22 characteristic movements of the exercises programmed in the iStoppFalls system. These movements were later simultaneously recorded by the Kinect sensor and the Kinescan / IBV® high-quality photogrammetry system. The error levels produced by Kinect and the Brownian movement model were obtained by comparing both sets of measurements and were used to "train" the particle filter.

The mean errors produced by Kinect and the improvement obtained with the particle filter are presented in figure 4 and table 1. Although the filtered angles with their mean error of $13.2^\circ$ are still imprecise compared to a good photogrammetry system, this is much lower than those produced by the sensor’s software. In some coordinates, the error may be reduced by more than $60^\circ$. Most of the residual error is...
caused by the rotation of the members in extension and a random-type noise that produces minor local oscillations. These corrected angles are used to calculate the ranges of movement associated with the active articulations during exercise, to detect postures and gestures and to award scores for the exercises and games. These scores are used by the fall-risk evaluation system and to deliver feedback that encourages the user to continue the training programme.

**Conclusions**

The development of the iStoppFalls system, with user movements monitored by the Kinect sensor, shows how the new low-cost technologies used in video games herald a real opportunity to apply the new strategies for evaluating balance and fall risk.

The precision of video game sensors is substantially poorer than those of laboratory equipment traditionally used in this area, but this limitation can be overcome using suitable methods of analysis. These procedures are based on signal filtering statistical techniques, entailing the need to define a compromise between precision and high frequency response. Increased signal precision will mean that fewer rapid movements are captured. Therefore, this type of tool is useful in cases in which precision and high frequency are not simultaneous requirements. The most appropriate type of tests for them are based on simple exercises, such as the detection of relatively broad gestures and ranges of movement, physical tests for the evaluation of risk of falls and the training programmes implemented in the iStoppFalls system.

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Kinescan/IBV V11: Real-time biomechanical assessment

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Rationale for the development of Kinescan/IBV V11

The mission of the IBV’s functional assessment laboratories is to objectively aid the specialist in the evaluation of a human being’s skills.

To fulfill their mission, laboratories have defined measurement protocols, systems that can capture the biomechanical variables that characterise the normal and sick population (regardless of their nature), expert information analysis systems and indices of clinical assessment criteria.

The target biomechanical variables are calculated using mathematical models that are fed by patient information, as well as by the study of the dynamics and kinematics of the movements they make.

Kinescan/IBV was developed due to the importance of recording the kinematics (changes of position over time) of human movements. This system, based on videophotogrammetry, analyses the movements of the different body segments when a given gesture is made in 3D.

Since 2003, Kinescan/IBV has been installed in more than 30 functional assessment laboratories and is used to assess the lumbar and cervical spine, shoulder and knee.

Due to the importance attached to kinematic analysis by the users of the IBV’s functional assessment labs, we have worked to ascertain the aspects that can enhance the Kinescan/IBV user experience. This work demonstrated that users would maximise the benefits of the IBV’s functional assessment labs if Kinescan/IBV V11 were able to:

- Reduce recording time.
- Reduce analysis time.
- Reduce the time taken to generate the results report.
- Improve measurement precision.
- Reduce maintenance costs.
- Improve reliability.
- Improve versatility for use in demanding exertions, such as sports.

What does the Kinescan/IBV V11 consist of?

As opposed to previous versions of Kinescan/IBV (Figure 1), the new Kinescan/IBV V11 system (Figure 2) is based on digital video technology with distributed pre-processing. This new system calculates the positions of the body segments automatically and in real time. Thus, the user can access data on the positions of points, body segments and articulations and of the derived kinematic and dynamic variables immediately after the gesture has been made. A complete 3D analysis...
of human movements can be performed quickly and simply thanks to the system's new features.

The development of the new version of the Kinescan/IBV system was developed as a complete renewal in the technical facets that afford the system its value:

- Lighting
- Video capture.
- Image analysis
- 3D reconstruction, precision.
- Graphic representation and results.
- Installation and maintenance.

**WHAT ARE THE TECHNICAL IMPROVEMENTS OF THE KINESCAN/IBV V11?**

The changes made to the Kinescan/IBV V11 have allowed the development of a videophotogrammetry system that is technologically far superior to previous versions. The new features of this equipment are:

- Increased reliability of the lighting system thanks to the LED lights.
- Improved lighting quality and homogeneity.
- Increased capture frequency.
- Increased resolution and precision.

- Increased flexibility in the configuration and number of lab cameras, thus permitting better adaptation to the gestures to be evaluated.
- No need to store video files.
- Automatic detection of anatomical models at the beginning of the measurement.
- Detection of patient instrumentation errors.
- Automatic real-time patient monitoring (Figure 3 and Figure 4).
- Greater precision in the 3D reconstruction by means of redundant detections.
- Automatic real-time processing of camera pictures.
- Real-time generation and presentation of the evaluation outcomes and reports.
- Straightforward installation and reduced maintenance costs.
A comparison between the most relevant technical specifications of Kinescan/IBV V11 and the previous versions of Kinescan/IBV V04 and Kinescan/IBV V08 shows the extent of the improvements to the system (Table 1). The comparison with the previous version of Kinescan/IBV V01 is not relevant, as the differences are much greater and the advantages are innumerable.

Table 1. Comparison of the characteristics between the different versions of Kinescan/IBV.

<table>
<thead>
<tr>
<th></th>
<th>KINSCAN/IBV V04</th>
<th>KINSCAN/IBV V08</th>
<th>KINSCAN/IBV V11</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum no. of cameras</td>
<td>4</td>
<td>4</td>
<td>Unlimited</td>
</tr>
<tr>
<td>Camera resolution</td>
<td>640x480 pixels</td>
<td>832x832 pixels</td>
<td></td>
</tr>
<tr>
<td>Frequency at maximum resolution</td>
<td>25 FPS</td>
<td>50 FPS</td>
<td>250 FPS</td>
</tr>
<tr>
<td>Image processing</td>
<td>On PC Delayed</td>
<td>On PC Delayed</td>
<td>Integrated in the camera In real time</td>
</tr>
<tr>
<td>Video storage</td>
<td>On Rack Hard Drive (1 PC per camera, 60 MB/ Lower back Assessment)</td>
<td>On Hard Drive (60 MB/ Lower back Assessment)</td>
<td>Not necessary</td>
</tr>
<tr>
<td>Reflection masking</td>
<td>NO</td>
<td>NO</td>
<td>Yes (by software, automatic)</td>
</tr>
<tr>
<td>Video Preview:</td>
<td>Yes, one camera only</td>
<td>Yes, several cameras simultaneously</td>
<td>Yes, all cameras simultaneously</td>
</tr>
<tr>
<td>Lighting</td>
<td>Halogen lamp with IR filter</td>
<td>Halogen lamp with IR filter</td>
<td>IR (850nm) LED Technology</td>
</tr>
<tr>
<td>Lamp mean service life</td>
<td>1 year</td>
<td>1 year</td>
<td>25,000 hours</td>
</tr>
<tr>
<td>Filter</td>
<td>YES (fixed)</td>
<td>YES (fixed)</td>
<td>YES (electromechanically switched)</td>
</tr>
<tr>
<td>Connection</td>
<td>Analogue video</td>
<td>CameraLink</td>
<td>Ethernet</td>
</tr>
<tr>
<td>Power supply</td>
<td>Wired, one power source per camera. Requires a 220V 50Hz socket.</td>
<td>Wired, one power source per camera. Requires a 220V 50Hz socket.</td>
<td>Ethernet (PoE). No additional wiring or 220V socket is required</td>
</tr>
</tbody>
</table>

**What benefits does the KINESCAN/IBV V11 deliver?**

All the technological improvements of the Kinescan/IBV V11 system make a significant contribution to improving functional aspects that increase the efficacy and reduce the operating costs of a Functional Assessment Laboratory.

Taking the NedRodilla/IBV application as our example, the improvements in efficiency are:

- At the beginning of the test there is no need to check that the markers are visible since the system does this automatically. The assessment can thus be performed once the instruments have been fitted to the patient.
- The greater number of cameras avoids defects in marker detection, even in patients that perform non-functional (abnormal or exaggerated) movements.
- Once the measurement has been taken, the system immediately confirms whether the result is correct, thus avoiding repetition of tests due to: loss of markers; lighting or camera errors; or darkening or glare, which occurred in previous versions of Kinescan/IBV.
- The applications generate the report immediately after the test. As the results are available at the time of the assessment, decisions on the patient are taken immediately (perform further repetitions, prescribe another test, perform a stress test protocol, discharge the patient), with the subsequent financial and efficiency benefits that are implied.

In many cases these improvements avoid the repetition of a test, thus making the most of the patient’s presence and in some cases sparing the patient a further journey to the assessment laboratory.

The Kinescan/IBV V11 also delivers improvements in terms of cost. Here are some of them (Table 2).

Table 2. Kinescan/IBV operating costs (example NedRodilla/IBV).

<table>
<thead>
<tr>
<th></th>
<th>KINSCAN/IBV V04</th>
<th>KINSCAN/IBV V08</th>
<th>KINSCAN/IBV V11</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time needed to perform a test (minutes)</td>
<td>60 min</td>
<td>40 min</td>
<td>30 min</td>
</tr>
<tr>
<td>Time needed to process the data (minutes)</td>
<td>90 min</td>
<td>60 min</td>
<td>0 min (immediate)</td>
</tr>
<tr>
<td>Time taken to repeat measurements due to errors in patient instrumentation (average)</td>
<td>25 min</td>
<td>15 min</td>
<td>0 min (measurements do not need to be repeated)</td>
</tr>
<tr>
<td>Costs associated with new journeys by the patient through errors detected “a posteriori” (average)</td>
<td>€10/assessment</td>
<td>€5/assessment</td>
<td>€0 (the validity of the assessment is verified in real time)</td>
</tr>
<tr>
<td>Time taken in the maintenance of hard drives, back-ups and emptying hard drives (minutes/assessment)</td>
<td>10 min/assessment</td>
<td>5 min/assessment</td>
<td>1 min/assessment</td>
</tr>
<tr>
<td>Cost associated with hardware maintenance: PCs, lights, cameras, cards, drives (annual)</td>
<td>€1,500/year.</td>
<td>€1,000/year.</td>
<td>€100/year.</td>
</tr>
</tbody>
</table>
Therefore, per laboratory **annual savings**, assuming 400 assessments a year, would be about **€15,000-25,000** (Table 3).

Table 3. Kinescan/IBV V11 operating costs savings. * Assuming an annual wage of €35,000 a year per worker at 1,760 hours a year.

<table>
<thead>
<tr>
<th>Personnel Time Savings</th>
<th>Savings in Other Costs (Travel, Maintenance, Repairs)</th>
<th>Total Savings</th>
</tr>
</thead>
<tbody>
<tr>
<td>With regard to the Kinescan/IBV V04</td>
<td>1,027 h €20,423*</td>
<td>€5,400</td>
</tr>
<tr>
<td>With regard to the Kinescan/IBV V08</td>
<td>593 h €11,792*</td>
<td>€2,900</td>
</tr>
</tbody>
</table>

This means that the investment in upgrading the Kinescan/IBV system in a functional assessment laboratory can be recouped in 2-3 years, particularly in labs with a Kinescan/IBV V04.

**Conclusions**

The new features of the Kinescan/IBV V11 system make Functional Assessment Laboratory applications faster, more rugged and more profitable tools.

The Kinescan/IBV V11 system is installed in all new laboratories. Laboratories with older versions may also be upgraded.

**Acknowledgements**

We would like to thank the users of the Kinescan/IBV system, particularly the users of Functional Assessment Laboratories, for their opinions, which help us identify ways of delivering an increasingly more efficient and objective patient assessment.

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Vocational guidance for people with cognitive disabilities

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INTRODUCTION

Vocational Guidance is a process intended to stimulate vocational interests and fit them to the subject's occupational skills and to job market needs. The first step in vocational rehabilitation is the choice of a realistic interest that will allow the subject to accomplish their occupational goal.

Good vocational guidance increases a person's chances in their search for a suitable professional career. Similarly, people who have received proper guidance have a greater chance of success in the world of work. On the contrary, the absence of work experience, lack of knowledge of one's own skills and abilities, lack of knowledge of the job market and people having the wrong impression of themselves are but some of the factors that lead to unsuitable vocational guidance. This is particularly apparent in population groups who, for different reasons, have more difficulties in finding or holding a job.

The objective of assessment in vocational guidance is identifying the user's employment interests, their occupational expectations, level of awareness and relationship with the job market, as well as their true work motivation. Vocational assessment methods include different techniques, such as questionnaires, the interview, direct observation, group dynamics, etc. The tools most frequently used by most professionals are questionnaires or inventories that allow them to probe different aspects, such as interests, motivation or preferences.

The advantages of traditional questionnaires and inventories (repeatability, information processing, validity, etc.) become drawbacks when the assessor has to deal with the following kinds of situations:

- Users who, for different reasons, do not feel comfortable with text-based interest questionnaires or do not make the most of them (people with cognitive or language difficulties, foreigners, etc.).
- People with a more visual style of learning (for example, people with hearing difficulties).
- When there is a suspicion that the questionnaires may be biased in some way (for example in the case of ethnic minorities) and may lead to a misinterpretation of results.
- Assessments seeking a more dynamic and less structured approach in the vocational assessment process, or when the aim is to collect more information than that which is provided by the tests, or complementary activities are to be performed.

In all these cases, the traditional questionnaires are not useful or are only part of the assessment and need to be complemented by other tools or techniques.
The **Jobpics** tool is presented on the basis of these premises. Jobpics was originally developed by the Association of Vocational Rehabilitation Enterprises (AVRE) of Norway by the occupational psychologist Arne Svendsrud. The Spanish version of Jobpics was developed by the Biomechanics Institute (IBV) through Jobpics-Europe, a two-year project funded by the European Commission's Leonardo da Vinci programme, presented by the SIU national agency (Norwegian Centre for International Cooperation in Higher Education). The purpose of this project was to develop versions of Jobpics in different languages and to adapt the method's characteristics to various national realities. The project partners were: AVRE (Norway), Louvi (Finland), IBV (Spain), Astangu (Estonia) and SOPA (Lithuania).

**PROJECT DEVELOPMENT**

The Spanish version of Jobpics was created using a work plan structured in the following stages:

1. Translation, interpretation and adaptation of the user’s manual and of the different information and guidance materials.
2. Adaptation of the Jobpics materials to the Spanish reality, including:
   - Characterisation of Jobpics users in Spain.
   - Selection of the most representative vocations, considering the structure of the Spanish employment market and the characteristics of potential Jobpics users.
   - Coding of the list of professions on the basis of the RIASEC system.
   - Photos of the 183 professions were taken.
3. Preparation of additional materials, including:
   - Market study on potential Jobpics beneficiaries.
   - Preparation of training material.

The result is the Spanish version of Jobpics, which the IBV has made available to professionals and organisations engaged in vocational advice, guidance and rehabilitation.

**JOBPICS**

**What is Jobpics and what is it based on?**

Jobpics is a new image-based vocational guidance tool. The use of Jobpics, alone or in combination with other techniques, allows professionals to work on the concerned person’s target vocational profile. As it is a very open tool, professionals can use it in different contexts and with forms of assessment adapted to the needs of each user.

Jobpics is based on the well-known RIASEC theory pioneered by John Holland, which classifies professions by categories of interests (**R**ealistic, **I**nvestigative, **A**rtistic, **S**ocial, **E**ntrepreneurial and **C**onventional). People can also be classified into 6 types of vocational personalities, based on their patterns of interests, personality, skills, values and motivation. From this standpoint, vocational guidance seeks to match person and vocation. The objective is for people to make vocational choices consistent with their profile.

Jobpics is comprised of 183 data files with pictures of professions. Each file is fronted by a main picture of the vocation, a code that classifies the vocation according to the RIASEC system and the level of training required. The back of each data file contains two additional photographs and related vocations that can be used to extend the assessment. The professional data files are accompanied by other process data files that make it possible to establish different forms of classification. These data files are included in a case with the user's manual.

![Figure 1. Items of the Spanish version of Jobpics.](image)

**Why an image-based tool?**

Many people do not feel comfortable with traditional pen and pencil-based tests, or are simply incapable of performing them. The target group are adults and young people in general, but particularly groups of people who have problems with written language (for example, people with reading and/or writing difficulties, limited language skills or attention deficit disorders). Some people also have a more visual style of learning (for example, people with hearing difficulties).

Moreover, in practice, images generate many more ideas and are more informative than text. Images are very descriptive and are conducive to a richer and more varied assessment in which the professional can design different types of sessions and strategies adapted to their clients' needs.

Jobpics is compatible with the use of traditional vocational assessment tools, particularly those based on the RIASEC system.

**How and where can Jobpics be used?**

The guided process with Jobpics provides for different possibilities:

- It allows the professional to systematically collect and classify valuable information on the user's vocational interests.
- It allows the user to reflect upon their interests, preferences and skills and thus identify, promote, consolidate and defend their strong points.

Jobpics can be used in different ways:

- As part of an individual application within a personalised assessment process.
Some of the possible specific applications of Jobpics are:

- Providing assessment in choosing education or vocational training.
- Facilitating job hunting based on interests and skills.
- Defining the user’s personal profile to facilitate the design of vocational itineraries (training, occupational, rehabilitation, etc.).
- Helping users to “discover themselves” as a form of support to decision-making.
- Stimulating user interests, preferences and skills (for example for writing résumés, preparing job interviews, etc.).
- Facilitating the occupational and educational rehabilitation process.
- Performing activities and games related to vocational guidance and to the discovery of the world of work.
- School guidance during the process that assists the student in study and in the period of adaptation to school.
- Complementing the performance of psychological tests and standard vocational guidance tests.
- Complementing the performance of psychological and personality tests in job recruitment processes.

Conclusions

The Jobpics tool is a novel instrument that facilitates vocational assessment by professionals working in this field. Its qualities make it particularly interesting for working with users with job placement problems, although it may also be useful in areas such as education or business.
Nasal mask for sleep apnea

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INTRODUCTION

The gasmedi company was incorporated in 1996 with the goal of becoming a reference operator in the Spanish home-delivered respiratory therapy and medicinal gas supply market. Gasmedi has two core divisions: the Home-Delivered Respiratory Therapy Division for the home treatment of patients with respiratory diseases; and the Hospital Division, which supplies medicinal gases to hospitals.

In recent years, the company has been delivering care to 120,000 patients while creating more than 500 jobs and opening 24 branches in Spain. It operates in fourteen of the seventeen Autonomous Regions, thus attending to 93% of the Spanish population. Gasmedi currently belongs to the Air Liquide Healthcare group.

The treatment of sleep apnoea by means of home-delivered Continuous Positive Airway Pressure (CPAP) is one of the services that Gasmedi offers. At present, the company must use external nasal mask suppliers to apply the therapy.

One of the project's main objectives was the development and manufacture of its own mask that would overcome, as far as possible, the drawbacks of current masks and would be easy to use for elderly people.

To accomplish this objective, Gasmedi, through its subsidiary, Servicios de Hospitalización Domiciliaria del Mediterráneo (SHDM), enjoyed the support of the Biomechanics Institute (IBV) in the application of people-oriented innovation methodologies. This methodology puts people at the centre of the product development process so they can add value to the different phases of the innovation process.

DEVELOPMENT

The most outstanding phases of the project are detailed below, showing how the people-oriented innovation model was applied.

Phase 1. Definition of user requirements

DEFINITION OF THE USER PROFILE

The usability and/or utility of the mask should be analysed by taking interactions with the user into account as well as the equipment, uses or tasks to which the user will put the equipment, or any environmental factors that may affect the equipment's usability. In this phase the user profiles were defined, taking the technical definition of the product and the needs the equipment is intended to cover into account.
The user requirements were defined via two channels:

- Ergonomic analysis
  Using the selected user profiles, the IBV analysed the mask design requirements, including the ergonomic and cognitive aspects that made it possible to detect possible product functionality and acceptability of the problems.

- Usability tests
  Several commercial masks were analysed with the help of users. The methodology used by the IBV makes it possible to carry out tests with real users, evaluate learning problems and design decisions. The product use tests were performed in the IBV Living Lab. The Living Lab is a versatile laboratory where different environments may be recreated according to experimentation needs. A comprehensive record of the interaction between user and product is obtained thanks to the different equipment in the laboratory.

  The usability test included the definition and performance of tasks adapted to the features of the product requiring evaluation. Besides the objective measurements, the users completed an opinion questionnaire in which they stated their overall satisfaction and provided a comparative rating of the different product features. The usability tests were performed on a representative sample of elderly users and on the reference products selected in the previous phase. This process helped to reveal usability problems, and the design requirements were then defined.

Phase 2. Definition of anthropometric requirements

The anthropometric requirements were obtained from a database with 3D scans of the heads of different subjects. These data were subsequently used to define, first of all, a series of anatomical points (Figure 1), which then yielded the different facial measurements. These measures were used as requirements that had to be taken into account during the design process so that the mask was adapted to the anthropometrics of the greatest possible number of patients and in order to segment the different sizes.

Phase 3. Product design

GENERATION OF CONCEPTUAL DESIGNS AND DESIGN SELECTION

The requirements defined in the previous phases were used to develop several conceptual designs of the new product (Figure 2). The models presented different alternatives to solve the mask’s key aspects, such as front support, harness or the join between the harness and the body of the mask.

The opinions of the actual users, as well as of the professionals and the company, were taken into account to select the model that would be developed in the detailed design work. Another important factor taken into account in selecting the definitive model was the estimated cost of manufacturing the product.

DETAILED DESIGN, MANUFACTURE AND USABILITY TEST

The detailed product design (Figure 3) was performed on the basis of the conceptual design selected. Some relevant and noteworthy aspects of the new mask include the 3-point harness, the clips that facilitate joining the harness to the mask and the cheek region pads. These key aspects aim to solve some of the problems detected in current masks, while also making the product easier to use by elderly people.

After the design process, a functional prototype was manufactured to perform product usability tests with elderly patients. Once again the IBV Living Lab was used for this
purpose. It was thus possible to check that the product developed fulfilled the requirements established in the initial stages and that it was therefore easy to use for the elderly. Similarly, the user evaluation of the prototype made it possible to detect the parts of the product that had to be redesigned to make them even easier to use by elderly people.

Conclusions

The application of the people-oriented model by GASmedi, with the help of the IBV, made it possible to:

1. Develop an innovative product that will enable the company to expand its business by extending its activities to the product manufacturing stage. It is very costly for companies to develop products without the collaboration of a technological centre such as the IBV, since most service companies do not have R&D departments.

2. Involve all the agents of the sector in the development of the new nasal mask.

3. Demonstrate that involving the professionals and users who apply the techniques and use the products, respectively, and leveraging the experience of the company rendering the service, is the best way to develop a product with optimal cost and quality.

4. Have an innovative product, used by the elderly, which will be manufactured in the Autonomous Community of Valencia, minimising costs but without foregoing product quality, contributing to the sustainability of the health system of Valencia and making companies competitive.

Acknowledgements

Project developed through the II Plan of Competitiveness of the Valencian Company (PCEV) of the IMPIVA, co-funded by the ERDF, within the ERDF Operating Programme of the Autonomous Community of Valencia 2007-2013.
Fully personalised glasses

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Introduction

MADE4U, a collaboration-based research project co-funded by the 7th Framework Programme, was designed to improve the competitiveness of European companies in the optical-ophthalmological sector through the development of new technologies and business models that permit the complete personalisation of glasses, frames and lenses, thus offering consumers glasses that maximise their quality of vision, comfort and satisfaction.

The project has made it possible to address new developments to personalise all the phases of the functional and aesthetic aspects of the glasses: marketing, design, production and logistics.

The main outcomes of the project may be summarised as:

-- New and totally personalised glasses concept. Unique glasses designed for each user, guaranteeing utmost vision quality and comfort thanks to a personalised lens design and ergonomic frame adaptation. The personalised glasses also include a personalised look, and the user collaborates in the design process according to their preferences (colour, shape, decorations...).

-- Development of new equipment for opticians. This personalisation is based on an innovative facial scanner for recording the person’s anthropometry as well as interactive joint development to personalise frame appearance.

-- Development of automatic design systems for frames, for ergonomic personalisation; and for lenses, to maximise vision quality.

-- Development of quick response manufacturing techniques for the personalised manufacture of frames and of the machinery that permits the personalisation of lens treatment and colours to make the personalisation financially viable.

-- Design and pilot testing of a flexible manufacturing network and a business model that facilitates responses to the demand for this type of product in a financially viable way for all the agents involved in the value chain.

These results are the fruit of 4 years of work by a European consortium comprised of 13 partners from 8 countries. Besides the IBV, this initiative featured the participation of INDO and ASCAMM, as coordinators, BRAECIS, EOS, K-INT, OPTICALCOM, PITA, PLASTIA, SATISLOH, TIPHERET, UAMS and XENNIA.

The Biomechanics Institute’s (IBV) contribution to the project focused on the user study. Firstly, the relevant variables of the person were studied for the ergonomic personalisation and the look of the frame. The definition of the people-oriented personalisation concept was also studied with the cooperation of 600 users and 68 opticians from

Full personalisation glasses

The possibility of buying personalised glasses is now even closer thanks to the results of the MADE4U project. This innovative and pioneering system for the design and manufacture of glasses is a first at worldwide level. IBV has contributed with the development of new equipment for opticians, a system for measuring the client and a co-design environment.

The measuring system consists of a scanner that records the anthropometric measurements of the face to achieve a personalised frame design. This scanner is easy to use; measurements are taken in mere seconds with little room for error.

As the glasses are totally adapted to user geometry, this system includes a virtual fitting room where customers can co-design the new glasses according to their preferences (colour, shape, style, decorations...) and simulate what they will look like on them.

Once the opticians place the order, quick response manufacturing technologies developed by the project partners, customers will receive a pair of glasses personalised according to their preferences, thus maximising comfort and quality of vision.
all over Europe. This information was used to develop the technology to capture the user’s anatomy and aesthetic preferences at the optician’s for the purpose of personalisation.

The two technological developments for the opticians, IBV’s contribution to the project, are presented below:

- A user morphometry capture system that scans the user’s face as the point of departure for the ergonomic personalisation of the frame geometry.

- A co-design environment, where the user can try the personalised glasses in a virtual setting, personalise the frame and the lenses and then complete the order with the help of an optician.

**System for capturing the user’s 3D morphometry at the optician’s**

At this moment in time, each frame model on the market has only one set of dimensions, or in some cases two. This lack of variety makes choosing a model complicated. Many frames simply do not fit the user’s face and are ruled out at the time of purchase, or are bought but subsequently feel uncomfortable during wear.

Ergonomic personalisation maximises wearer comfort by modifying the geometry of a frame model, since glasses are totally adapted to face size. The user's facial anatomy must therefore be recorded to offer them personalised glasses.

The system developed by IBV (Figure 1) records the user’s facial morphometry at the optician’s in a very simple way. The system scans the user’s face and pupils and performs a synchronised calculation of the person’s measurements, after which the frames can be designed according to the user’s characteristics.

The equipment operated by the optician in hardly two seconds performs a full-face scan (also detecting the key anatomical points in the personalisation) and records the client’s measurements to be sent and used in the design.

The system is based on photogrammetry and artificial vision techniques and boasts a precision of up to 0.5 mm in pupil detection and 3D facial reconstruction. The user is scanned standing up, in a neutral stance, a requirement for predicting the variables pertaining to the centring of the lens on the frame.

**Co-design environment for aesthetic personalisation**

The co-design system provides support to the personalisation of the appearance of the glasses, and has been developed to ensure a user-friendly experience for clients and also adapted to the optician’s selling process.

The environment allows the client to personalise their glasses personally, selecting frame model, colours, and the finishing of the front part and of the finish and the temples. They can also add decorations (Figure 2). With this module, lens colours and surface treatments can also be changed in order to achieve fully personalised glasses.

In order to facilitate the design process, the environment has a virtual tester where the client can demo the glasses they are designing, adapted to their dimensions, viewing the modifications in real time on their face (Figure 3). As these glasses are unique, in the sense that they are made for each user and they are not actually available at the optician’s at
Once the measurements have been taken and the design has been personalised, the optician places the order, and thanks to the quick response manufacturing technologies developed by the project partners, the client will soon have their 100%-personalised, and therefore unique, glasses (Figure 5).

**Conclusions**

The systems developed at MADE4U were tested in a three-month pilot test at Óptica PITA (Portugal) and Un Certain Regard (France) with real clients, where a total of 112 personalised glasses were manufactured.

The clients’ opinion of the new personalised glass purchasing experience was very positive. In the evaluation of the morphometry capture system, 94% of clients considered the scanning process comfortable, while 84% even stated it was fun. As for the co-design environment, 95% of clients felt that the virtual tester was useful. The environment was also positively rated by 93% of users.

IBV, in collaboration with INDO, has developed this innovative and pioneering service for the design and manufacture of glasses, demonstrating that personalisation allows companies to stand out in the highly competitive optics sector.

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