Design and Development of the First Prototype of a Social, Intelligent and Connected Help Desk

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Abstract: This paper presents an innovative architecture of help desk in the tourism environment. The aim of the work, performed with a professional woodworker manufacturer, is to design an interactive counter, integrating the methods and the technologies of robotics. The idea is to provide customers with a new experience, based on an intelligent and social interaction within a connected environment, using wood as the main material. In order to achieve this objective, modular hardware and software architectures have been designed and the first prototype is under development. The paper focuses on the description of the architecture of this prototype and on the first results obtained.

1 INTRODUCTION

A help desk, or counter, is not only a piece of furniture, it is the entry/exit point of commercial, administrative or cultural entities, public or private, having a physical access. The help desk represents the physical interface where customers and service providers in tourism get in touch and interact. Examples of service providers are hotels, restaurants, tourist offices and so on.

In this context, modern technologies can provide new forms of interactions and ways to deliver services, thus contributing to enhance customer experience, or user experience (UX). UX consists in providing a usable, useful and enjoyable service or product (Rogers, Sharp and Preece, 2011). UX is a matter of emotions before, during and after use. It is how a product feels (Allabarton, 2018).

A lot of work can be found in literature about pieces of furniture or more complex systems, able to interact with customers through technology. Innovative kiosks designed as information points have been the object of many publications. Niculescu, Yeo and Banchs (2016) propose a device for shopping mall, based not only on tactile but also on vocal interfaces, while in the work of Bergweiler, Deru and Port (2010) tourists can even share information through a similar tactile device. Focused on the development of a social conversational agent, the work of Cassell et al. (2002) proposes the analysis of speech, gaze, gesture and body posture to better give to the visitor the demanded direction. Finally, the system designed for smart cities and described by Gomez-Carmona, Casado-Mansilla and Lopez-de-Ipiña (2018) points out the importance of taking into account emotion bond, personalization and technology appropriation by the user in kiosk design.

Other than kiosks, the work described in Omojola et al. (2000) presents a table installed in a museum projecting contents from the ceiling. Tagged objects enable information selection. The interesting idea of this project is to provide the visitor with an intuitive and unobtrusive information interface non neglecting the aesthetic of the visual appearance. Another interesting design approach to furniture design for workspaces is proposed by Campos, Ehrenberg and Campos (2018). In this work it is pointed out how a multisensory approach and ergonomics can affect productivity in a workplace.

An original work and application is proposed by Schafer et al. (2018), that presents an instrumented room to help fighting against illiteracy. This room is used by librarians to engage a group of children in a multi-sensory read-aloud of a printed picture book.

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The system can be programmed to play sounds, lights and movements to create scenes. The idea of plunge the user into an atmosphere is very inspiring, but the user interaction with the system is limited to a touchscreen tablet.

Some of these technologies are now industrial products. Restaurants, bars and hotels integrating interactive environments and even robots can be found all over the world. The Tipsy robot in Las Vegas, for example, is an installation integrating two industrial Kuka robots, that prepare cocktails created by customers (http://thetipsyrobot.com). A social and connected environment allows customers to share recipes, to rate favourite and some other features. In the Inamo restaurant in London (https://www.inamo-restaurant.com) the atmosphere can be tuned thanks to a 360° projection of a real spot or of a completely virtual world. Tactile bar counters, reactive to bottles and glasses, are today available, as the products proposed by Kineti (http://kineti-technologies.com). In Asia, high-tech restaurants and hotels even employ robots as waiters or receptionists. As an example, it is possible to be served by robots at the Chinese Freshippo supermarket. Most of these industrial products show poor multimodal interaction and favour one technology. They have a reduced field of applications and are difficult to use if either the environment or the customer's need changes. Moreover, they are extremely costly, therefore their spread is very limited.

The system proposed in this article aims to integrate existing low cost technologies in a modular and scalable architecture, able to provide multiple services. The final objective of such a system is to enhance UX, by creating an emotional bond with the customer. This is achieved by guiding the customer through a unique experience by means of multiple multimodal interactions, carefully integrating aesthetic design and choice of materials. Recent studies have indeed investigated that wood-based interior products improve customer touch experience (Bhatta et al., 2017) and have positive physiological effects (Ikei, Song and Miyazaki, 2017). As a result, our system design is performed in close collaboration with a professional woodworker specialised in counter manufacturing. In addition, the participation to the project of a design professional contributes to ergonomics and aesthetic of the final outcome.

None of the system found in literature or among commercial products deals with all these aspects. The application addressed by this system is the tourist field, but the concept can be easily adaptable to any environment integrating a help counter.

The paper is organized as follows. In Section 2 the basic concept is presented, while in Section 3 the main technological choices are introduced. Section 4 describes the prototype and Section 5 presents the first results. Section 6 concludes.

Since the acronym of this project is CISC (Comptoir Intelligent Social Connecté, which means intelligent social connected counter), we will refer to the help desk as the CISC counter or simply as CISC.

2 THE BASIC CONCEPT

CISC consists of several physical interactive counters, called modules, organized within a zone, called interaction area. The main idea is that the customer's interaction with CISC is supported not only locally at each module, but all over the area. This enables a smooth and intuitive interaction all along the customer's path, proving a higher quality UX.

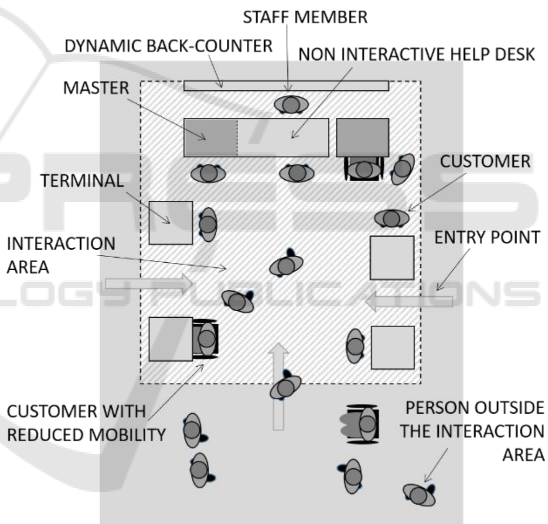

Figure 1: CISC basic concept.

More precisely, our concept is illustrated in Figure 1. As the customer enters the interaction area, his/her movements are tracked in real-time. This information can be used to help the customer to find the way to terminals, to optimize system layout and to improve customer flow. As the customer enters the interaction area, an agent is allocated to him/her. The agent is the unique entity created by the system for that customer. It guides and assists the customer during his/her interaction with CISC.

Within the interaction area, nearby a non-interactive help desk managed by a human staff member, there is at least one module, called master. Depending on the number of customers to be welcomed, additional masters can be installed. One or more physical secondary modules, called terminals, are also installed. This modular architecture allows the adjustment of the system configuration according to the environment (amount of attendance, building configuration, cost, etc.).

Customers can access the area from any point, but the first action they should perform is to head to one master, in the same way a customer looks for a free staff member in a tourist office. A dynamic back-counter behind masters aims to draw the customer's attention before the beginning of the interaction. It is also used to enhance system communication with the customer during the interaction. Masters present to the customer the services available in the area (including those provided by staff members) and record customer preferences: for example, they enable to choose the language. Preferences are stored by the system and transferred to terminals, that provide services. That's why terminals do not activate themselves in front of a customer that hasn't registered to a master. Terminals are stand-alone modules that can be plugged or unplugged to the system and that communicate with it. The technology that they integrate depends on the provided service(s).

All modules, masters as well as terminals, are "console" shaped (bended table), as it can be observed in Figure 2.

Figure 2: Example of a console shaped master designed by the professional designer of the project.

In this way, all modules are completely accessible for wheelchairs. They are designed by the professional in the field of interior design for commercial and business environments, partner of the project. Moreover, modules are entirely manufactured by the professional woodworker, also partner of the project. High quality wood and other special materials are carefully selected and assembled.

The presented concept has the main objective of enhancing UX and of providing effective help to staff members. That's why design specifications focus on the following key aspects:

- An intelligent desk, able to deliver a customized service by identifying the customer (with no connection to his/her real identity), by storing interests and preferences. Staff members can also use the data to improve offers and services.
- A social desk, able to pertinently react to customer's behaviours such as hesitation, doubt, immobility. It also assists the customer during the interaction.
- A connected desk, able to create a bond between the customer and local environment (touristic attractions, product, etc.). Wood is chosen as the main material to convey emotions and create this bond.

These key design objectives have driven our main technological choices.

3 MAIN TECHNOLOGICAL CHOICES

The CISC concept relies on a modular and scalable design, based on a multi masters/multi terminals hardware architecture. For the software architecture we use ROS Robotic Operating System. The reason is the need of:

- Modularity. The CISC design and configuration are intrinsically modular. The number of modules as well as the services available are always different, according to staff and customer needs.
- Parallelism. Many people (customers and staff members) can interact with CISC at the same time and the system has to respond in real-time.
- Technology adaptability. CISC integrates existing technologies and is meant to evolve over time. Many input/output devices are already integrated in ROS and are immediately available.

3.1 An Intelligent Desk

In order to be able to identify the customer and to track his/her path within the interaction area, a badge based on active RFID (Radio Frequency IDentification) technology has to be collected by the customer before entering the area. The action of collecting a badge has a precise meaning for the customer interacting with CISC. It is a choice, a will of beginning an interaction that ends when the badge is given back. The work of Fossdal and Berg (2016) directly inspired us in building this scenario. The badge is necessary to activate the different modules and allow the recording of the customer activity. The badge is the agent, previously introduced. The active RFID-based system is developed by a company specialized in IoT (Internet of Things), partner of the project. An advantage of this method with respect to image processing performed by cameras is the robustness of customer tracking in crowded environments. Another advantage is that the customer can remain anonymous. The system doesn't store any personal data without consent in compliance with the EU General Data Protection Regulation (GDPR). A customer can record only willingly the profile for a further visit.

3.2 A Social Desk

In order to be able to interact in a natural way with the customer, a main strategy based on Artificial Intelligence techniques is under development. At the master, a low cost camera captures a video stream that is analysed by the OpenPose library (Cao et al., 2018). This open-source library is based on a neural network algorithm and provides in real-time and in a robust way the position of arm and body segments. The idea is to detect hesitation, immobility or inactivity, bad manipulation caused by accident (error) or voluntary (not "playing the game").

3.3 A Connected Desk

The main application of our desk is assistance in the tourism field. Since the system is highly modular and reconfigurable, it can be installed in tourist offices, hotels, restaurants, museums and so on. The desk can operate autonomously or coexist with human operators, according to the specific needs of the environment. The idea is to create a connection between the customer and the touristic local activities, services and/or products by means of multiple human-machine interfaces, having multiple interaction modalities, e.g. tactile, gestural, visual. In order to provide an original UX, our system integrates wood in these interfaces.

4 THE PROTOTYPE

The first prototype of CISC is under development. Figure 3 shows the overall architecture of the system. The use case addressed by the project is the tourist office. A master with a moving wall and two terminals are placed within the interaction area.

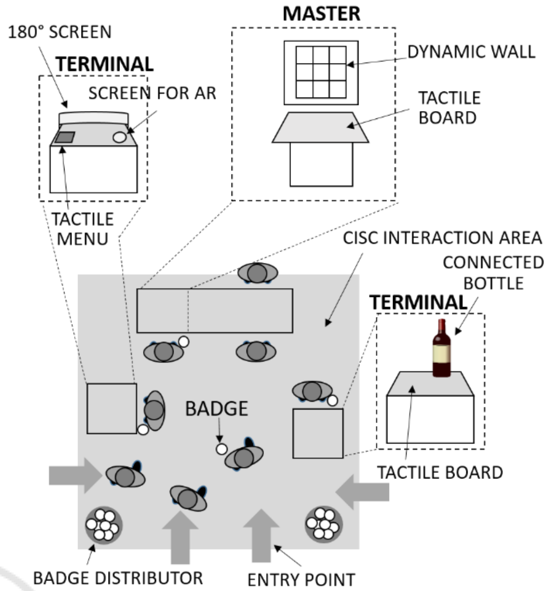

Figure 3: Architecture of the first prototype.

4.1 Prototype of the Master

Figure 4 shows a picture of the very first prototype of the master.

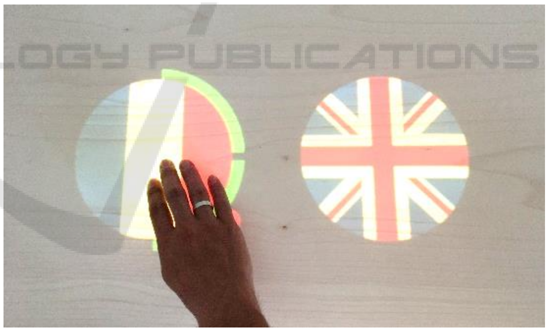

Figure 4: First prototype of the master.

The customer stands in front of the wooden console. A 60cm × 40cm graphical user interface (GUI) is projected through the console from behind by a video-projector. An example of what the customer sees is showed in Figure 5.

The wooden console appears "transparent" to the customer thanks to a particular assembly process. The console is made of a board of transparent PMMA (polymethyl methacrylate), covered by a 0,6mm layer of wood. The customer interacts with the wooden board as if it were a tactile surface. A schematic view of the master is shown on Figure 6.

Figure 5: Picture showing the transparent wooden table.

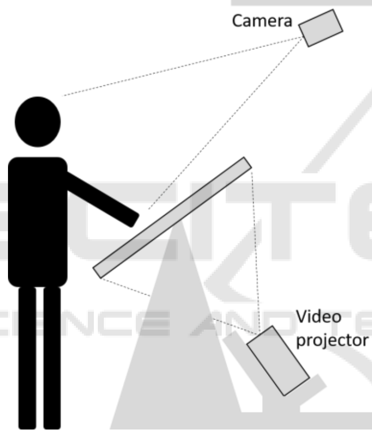

Figure 6: Schematic view of the master.

As previously mentioned in section 3.2, OpenPose analyses in real-time the video stream provided by the camera, in order to detect the position of customer joints. Figure 7 shows an image processed by OpenPose.

OpenPose is able to detect the hand position, but the computing requires too many resources and system performance drastically slows down. That's why our software uses the position of the customer wrist to interact with the GUI. "Selectable" areas are defined for each screen. Thus the position of the wrist with respect to these areas, can trigger item selection. In this prototype, the customer has the possibility to select a language between French and English and a service, between wine discovery and restaurant exploration.

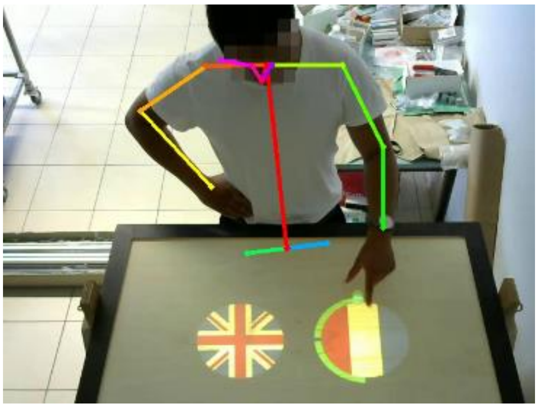

Figure 7: Picture showing the result of OpenPose processing on the video image.

In order to enhance the CISC interaction with the customer, a dynamic wall is placed behind the master. The aim of the wall is to draw the customer attention and to provide original interaction and help. In order to draw different patterns, the wall is composed of thirty cubes of 10cm side, arranged in a 6x5 matrix. Each cube can move back and forth of a tuneable depth. Cubes are made of corian®, a composite white material that can diffuse light. Six programmable RGB LEDs WS2812B are therefore fixed in the inside of the cube. Each cube is fixed on a ball bearing runner and is independently driven by a servo motor MG945 from TowerPro. A servo driver and a programmable electronics allow the simultaneous and independent control of each cube. Figure 8 shows the first prototype of cube and the final CAD design of the optimized cube.

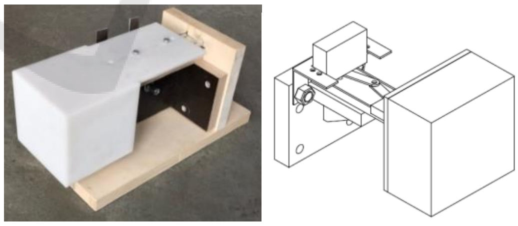

Figure 8: First prototype of moving cube on the left, manufactured by the professional woodworker of the project. Final CAD design of the cube on the right.

The software architecture of the master, based on ROS middleware, is showed in Figure 9. The main role of the CISC node is to activate an Agent node for each customer in the interaction area. The agent is the entity that is associated to the customer. It stores customer preferences, that are saved and transmitted to terminals whose services have been booked. Therefore, a communication node is responsible to send and receive data from the master to the terminals and vice-versa. Data consist of customer choices (e.g. types of wine or restaurant, particular plate) and time spent on each choice.

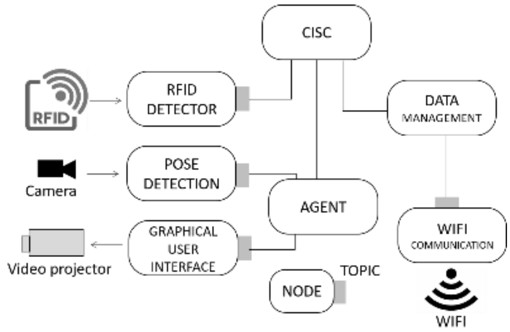

Figure 9: ROS architecture (nodes and topics) of the master.

4.2 Prototype of the Terminals

Two terminals are under development. All terminals have a similar geometry, dimensions and architecture. They are activated by the badge and they are connected to the master by Wi-Fi. The activation of the terminal is highlighted by a ring of programmable RGB LEDs. We use a Raspberry Pi 3 B+ electronic board to control all the input/output devices. A first terminal presents the wine production of Occitanie, a region of France. A second terminal presents the restaurants of Toulouse, a town in France. Only the wine terminal is presented in details.

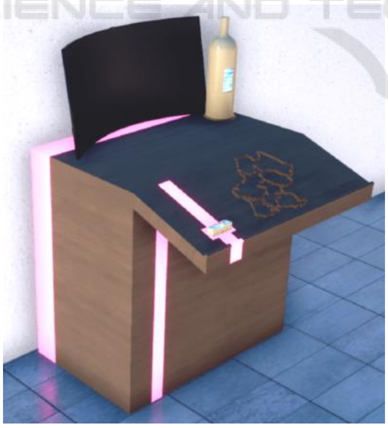

Figure 10: The wine terminal designed by the professional designer of the project.

Figure 10 shows an image of the wine terminal while Figure 11 shows the architecture of the wine terminal. The customer can select a department of Occitanie by touching the corresponding area on a map engraved (by a laser printer) on the wooden board. A wooden bottle, integrating a 4,3” touch screen, communicates with the terminal by Bluetooth. It allows the visualisation of different information about wines, corresponding to the selected areas. The bottle is autonomous in energy and can by grasped by the customer. Capacitive technology is used to make the wood tactile (map). On the bottom of the board, electrodes are painted with conductive ELECTRIC PAINT™ from BARE Conductive. The customer hand is the second electrode of the capacitance, whose variation are measured by the CAP1188 capacitive touch sensor. Sensitivity and threshold tuning for each sensor enables to reach a stable configuration. Sensor input determines the activation of the bottle.

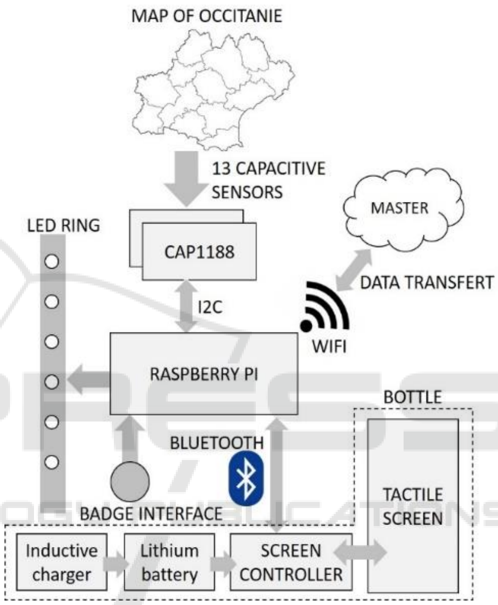

Figure 11: Architecture of the wine terminal.

5 FIRST RESULTS

The results of this section address technical issues of the design and the implementation of the wooden-based interfaces previously presented. The complete CISC prototype is still at a development stage and it is too early to perform UX tests.

First results concern the tactile wooden surface at the master. A preliminary testing campaign has been performed. 15 people, male and female aged from 20 to 50, interacted with the master for 2 minutes. A GUI composed by several sub-menus, has been programmed for these tests. This campaign pointed out an instability in wrist detection, leading to troubles in obtaining a stable area selection. The implementation of a Kalman filter solved this issue.

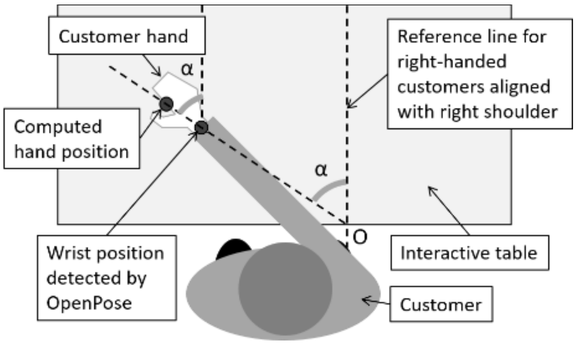

Figure 12: Adjustment of the right hand position. A similar procedure is applied to the left hand. Alpha (α) is the angle between the reference line and the wrist-O line.

Tests also revealed another problem. The users found particularly difficult the selection of interactive areas on the top corner of the screen. Because we use the wrist position to compute the hand position (see section 4.1), we have to adjust the computed coordinates of the hand (see Figure 12) on the reference frame of the GUI.

Table 1: Materials tested with the pattern.

Material	Thickness in mm
Wood veneer pressed wood	18
Stratified veneer pressed wood	20
3-ply plywood picea	19
Glued laminated hevea	33

Concerning the tactile surface of the wine terminal, a set of tests have been performed on different panels (see Table 1), in order to select the most suitable material for the integration of capacitive sensors.

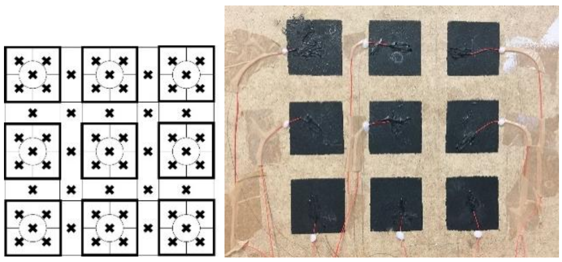

Figure 13: On the left, the 61 spots tested for each material. On the right a picture of the electrodes positioned on the bottom of each panel.

On the bottom of each panel, we placed a pattern, made of 9 square painted electrodes of 5cm side, separated by a space of 2cm (interstice) and arranged in a 3x3 matrix. Each electrode is connected to the capacitive sensor (see Section 4.2).

We asked the test users to touch the wood plate on points aligned to the spots, labelled with a cross on Figure 13. For each electrode, 5 spots have been tested, as well as spots in interstices between electrodes. A contact is detected if the sensor value exceeds the sensor threshold. Normally, when touching spots between electrodes (in interstices), none of the adjacent sensors should detect a contact.

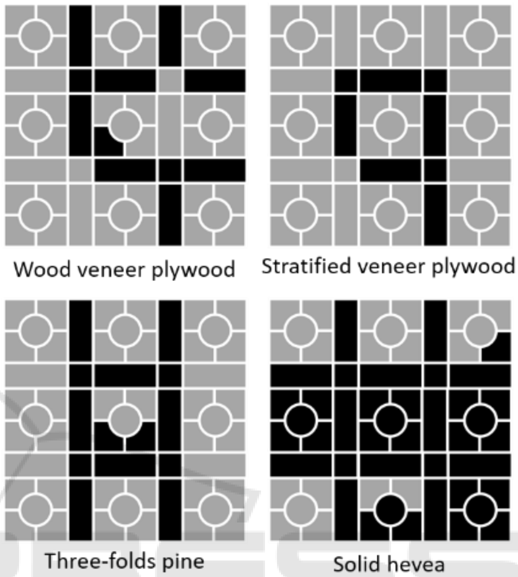

Figure 14: Results obtained for the 4 types of material. A spot on the electrode in black colour means that the sensor didn't sense the contact (unexpected result); grey colour means the opposite (expected result). In a similar way, a spot on the interstice in black colour means that none of the adjacent sensors detected the contact (expected result); grey colour means that one of the sensors immediately adjacent to the interstice detected the contact (unexpected result).

Figure 14 shows the results obtained with fixed sensor sensitivity and threshold. For the tests, the sensitivity is fixed to 0,5%, which corresponds to a maximum capacitance variation (ΔC) detection of 150fF from a 30pF base capacitance. The threshold is an integer value between 0 and 127 and is fixed to 120, that corresponds to a threshold of about 140fF. The results show that sensor response can be adjusted by varying sensor sensitivity and threshold. Nevertheless, for a low value of sensitivity, as the one used for the tests of Figure 14, for 3 materials over 4, it is hard to avoid the activation of a sensor when touching an interstice. Therefore, solid hevea has been chosen for the final prototype.

Figure 15 shows how results vary by modifying sensitivity and threshold for the same panel.

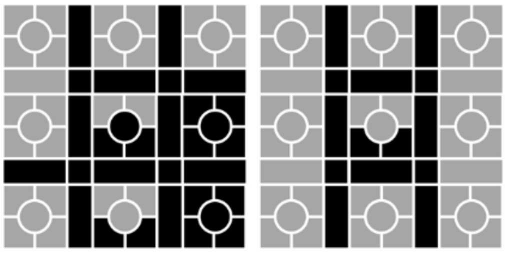

Figure 15: Results obtained with 3-ply plywood picea.

6 CONCLUSIONS

In this paper we have presented an innovative architecture of help desk for tourism environment. A first prototype including a master and a terminal has been built. First results show the consistency of the wood-based human-machine interface. Extensive tests will be now performed to improve software and hardware architectures in order to fully satisfy the CISC concept: to integrate available and low cost technologies in an original design and architecture, in order to provide the staff of a touristic business or service with a powerful working tool and to provide the customer with a unique user experience. CISC is designed as a service provider, meant to be intelligent, social and connected. Finally, its modular design and architecture makes it adaptable to many environments, applications and budgets. User studies and data collection will then be conducted.

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