Tactile Camera vs. Tangible Camera: taking advantage of small physical artefacts to navigate into large data collection

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ABSTRACT
This paper presents the design and evaluation of two interaction techniques used to navigate into large data collection displayed on a large output space while based on manipulations of a small physical artefact. The first technique exploits the spatial position of a digital camera and the second one uses its tactile screen. User experiments have been conducted to study and compare the both techniques, with regards to users’ performance and satisfaction. Results establish that Tactile technique is more efficient than Tangible technique for easy pointing tasks while Tangible technique is better for hardest pointing tasks. In addition, users’ feedback shows that they prefer to use the tangible camera, which requires fewer skills.

Keywords
Interaction technique, mixed interactive systems, pointing task, usability study

ACM Classification Keywords
H5.2 [Information interfaces and presentation]: Input devices and strategies – Interaction styles

General Terms
Design, Experimentation, Human Factors

INTRODUCTION
Through the use of metaphors, direct manipulation and exploration of different modalities combined or not, the reduction of the execution and evaluation gaps [30] has always played a major role in the development of interactive systems. It led to the emergence of novel interaction techniques, especially for mass-market systems. Nowadays, as underlined by [12] and [17], recent advances adopt a new approach for reducing these gaps: it consists in focusing on users’ aptitudes and their environment. This approach therefore promotes a better integration with the physical environment of the user by merging the use of physical artefacts and digital capabilities.

As a consequence, different paradigms and interaction forms emerged including mobile interactive systems, tangible user interfaces, mixed reality or tabletop interactions. Following their breakthrough in specific application domains such as, maintenance, surgery, learning or military applications [1], demonstrating their technical feasibility, these new forms of enriched or embedded interaction spread themselves in numerous public spaces, such as classrooms [23], sightseeing places, public transports and museums [5,11].

Figure 1: Luminous Table for Urban Design Course (http://web.mit.edu)
**Interaction in Public Spaces**

In such public contexts, designers often provide large displays, tightly integrated into the environment, using video-projection or wall-screens. This is more and more prevalent when several users simultaneously interact with a large amount of information, such as a bus network, a site map, museum or artistic exhibits. Therefore, studies on the interaction with large data collections triggered new representation forms and interaction metaphors [7], or combination of representations [33]. However interacting with these display surfaces most often results in basic interaction techniques [24] because little attention has been paid to the study of their characteristics and impacts.

Meanwhile, the miniaturization of technologies raised the amount of small devices able to capture physical information and process digital data. They are even integrated into personal objects such as cellular phones, PDA or digital cameras for example. They support access, navigation and selection of data, but constrain the interaction spaces in terms of size. However, these objects are familiar to users: learning to manipulate them has to be done only once and the fear of using new technologies may be reduced.

Therefore, our work explore a current challenge in public interactive spaces: successfully combining the use of small personal belonging, providing a spatially limited and constrained input interaction space, with the need of pointing in wide output interaction spaces such as large displays.

**Physicality-based Interaction Techniques for Remote Pointing**

To contribute to this challenge, two interaction techniques were developed that exploit the physicality of a personal digital camera to navigate a large collection of pictures rendered via a large display. The exploitation of the digital camera provides two different user’s input interactions with a data collection:

- The first version takes advantage of the object itself, its position and its ability to be moved by the users; it is therefore a tangible interaction;
- The second technique takes advantage of its tactile surface to capture the position of a finger or a stylus; it is therefore a tactile interaction.

In both versions, the detected position, respectively of the camera and the stylus, is used to move a pointer in the pictures collection. This pointer is controlled through the so-called Softstick, a software enhancement allowing a modal behaviour of the interaction and a control of the pointer’s speed. To assess the adequacy of small physical artefacts to support the input interaction with a pointing task in a large output space, a user test protocol has been defined and applied: it aims at evaluating the usability of the systems, especially both performance and satisfaction.

The aim of this paper is thus to 1) present the two interaction techniques dedicated to the pointing in large space and, 2) to summarise results of the user-test comparing these two interaction techniques. First section synthesised existing interaction forms with large displays and physicality based interaction. Then, the implementation of the proposed interaction techniques is detailed. Finally, the two last sections describe the experiment and its main results.

**RELATED WORKS**

With regards to the use of small devices for navigating through large data collections rendered via large displays, related works can be analysed through three different aspects: existing approaches for interacting with large displays, interests and forms of Mixed Interactive Systems (MIS) and finally optimizations of pointing tasks.

**Devices Used with Large Displays**

Using a mouse to interact with large displays remains difficult since a display size larger than the input size deeply affects the pointing of distant targets [32]. Moreover, users are standing in front of large displays instead of sitting at a desk and therefore the use of traditional pointing devices is precluded. Considering these two facts, several works introduced some pointing devices to facilitate the interaction with large displays.

Among the proposed solutions, technologies enabling a direct pointing on displays constitute the main trend. The tracking of stylus [29] or pen [19] on whiteboards can use ultrasonic or infrared recognition. Direct tracking of users' fingers is also implemented using visual recognition in infrared range [20] or visible range [27]. If pointing performances are satisfying [13], direct pointing constrains users to move around the display if targeted objects are not within reach. On very large displays, users can even not access to some areas especially with vertical displays. Therefore with direct pointing, interaction possibilities are dependent of the displays configuration. To avoid such a limitation, distant pointing is available with laser [10], eye-tracking [34] or freehand technique [35]. However, distant pointing lacks precision, especially when targets are small.

In this context, 3D input devices can be used to support an indirect pointing [28]. It involves different input and output interaction spaces and can offer new perspectives. But it highlights three problems: 1) the use of a specific input device: it is not always relevant especially in public spaces, 2) the discontinuity of the interaction: input devices may require some users’ attention too, 3) the difference of scale between input and output spaces. Therefore, a promising way to consider should be the development of new interaction techniques, such as Mixed Interactive System (MIS), since they propose a wide range of devices, more customary to users and with larger interaction capabilities.
Mixed Interaction Interests
In public spaces such as museums, getting used to an interactive element is rather rare, because users do not visit these places on a regular basis and interactive elements may be rapidly replaced with new ones. Rather than offering traditional desktop devices, an ecological design of the interaction techniques may lead to the use of the environment artefacts and/or the users’ own resources: this will contribute to the users’ appropriation and learning of the technique. The main objective of novel interaction forms such as MIS, tangible UI, ubiquitous and pervasive systems, is to populate the interactive space with physical elements: any artefact, the architecture, the ambient light or sounds are therefore potential interactive elements [22].

Given the technologies involved, mixed interactions have a great potential for taking into account a wide range of physical dimensions: users or objects positions [21] or body gestures [2] are some examples. These possibilities now offer new ways of using the environment: by using water, bricks and clay [31] as interactive support instead of keys and buttons, by using image walls, see-through devices, and also light intensity, colours or gas pressure as feedback instead of only pixels. Such a potential opens up the design space of interactive systems that best fit the situation. Any physical artefact may be involved and related to a digital concept to define the best interaction according to the environment and the users’ goals and/or expectations.

Involving MIS in public spaces is therefore a promising route. In addition, MIS can be more customary to users since their components may already be present and manipulated in the spaces; MIS can be more attractive because of their novelty and their use of common objects; finally MIS reduce the problems of damages or robbery since it can be based on artefacts owned by the users themselves. All these characteristics participate to a better acceptance by visitors that can increase the possibilities of knowledge transmission targeted in classrooms, museums, sightseeing places, and all public spaces.

However, when dealing with indirect pointing in large spaces, it is also necessary to put attention to the task itself and the way to optimize it.

Optimization of Pointing Tasks
Reducing the time needed to accurately point at distant targets is a problem already well studied and which produces many software solutions. Among them, three predominant forms of approaches emerge: they either propose to increase the speed of the pointer in empty spaces [6], or to always select the closest target [16,18] or to increase the number of on-screen pointers [7,25]. These techniques are effective when the number of targets displayed on screen is limited.

However, if the pointer flies multiple targets before reaching the desired target, these techniques are no longer effective. Therefore interacting with pictures collections, which include few empty spaces, cannot take advantage of such kinds of optimizations.

DEVICES FOR REMOTE POINTING
As enounced above, the main objective of our project consists in navigating into a large amount of data, actually a large collection of pictures (Figure 3) projected on a white wall. It is intended that users of our techniques have the possibility to navigate their own pictures: therefore the main design idea is to use their own digital camera as the primary interactive device. With this physical element, we propose two forms of input for pointing at pictures: 1) using a video-based localisation of the camera and 2) using the embedded tactile screen of the camera. Since such input techniques offer a quite limited range of input interaction values, they are combined with a digital tool, the Softstick further described in the following section.

Description of the Softstick
The Softstick is a software tool used to control the position of a selector on a display. The centre of the Softstick representation gives the position of the selector. The rest of the Softstick representation, a disk and a pointer, provides a feedback related to its behaviour. Indeed, one position of the interaction technique controlling the Softstick corresponds to one position of the pointer in the Softstick; in addition, the position of the pointer determines the motion (direction and speed) of the whole representation of the Softstick, i.e. of the selector displayed in the data collection. It thus supports a modal interaction to pilot the selector.

![Figure 2: the Softstick components](image)

In concrete terms, the representation of the Softstick is composed of a disk with a specific radius and a circular pointer (Figure 2). The input technique drives the pointer inside the Softstick disk: the Softstick disk therefore represents the available input interaction space. Above a predefined threshold of motion of the pointer (10% of the radius), the Softstick starts to move. That motion (u) is performed using as direction and speed (with a logarithmic
function) the vector (v) between the Softstick’s centre and the pointer. Therefore, the motion speed increases when the pointer moves away from the centre.

Having such behaviour and representation, the Softstick is able to manage the scale difference between a small input interaction space and a large visualisation space. Its modal behaviour has also consequences on the user’s physical actions and their number: clutching is avoided and thus reduces the appearance of musculoskeletal disorders.

Input Techniques
To control the behaviour of the pointer in the Softstick, two input techniques have been defined. In the first one, position of the Softstick’s pointer is associated with the location of the camera held by the user. The location of the camera is computed using marker-based video recognition; therefore a tag is placed on the camera. As a result, users interact with the pointer through wide arm motions: such non-fastidious motions limit the need of skill and focus for performing the actions.

Conversely the second input interaction technique proposes smaller movements to interact with the Softstick. This technique is based on the use of camera’s tactile screen. This screen is actually simulated with an UMPC, providing a 7-inches tactile screen and unrestricted software capacities. In this setting the user manipulates a stylus to control the position of the pointer in the Softstick. Although no data are displayed on the tactile screen, each position of the stylus on the tactile screen corresponds to a position of the pointer in the Softstick.

These two input interaction techniques have been connected to the Softstick and used during user-tests with a large collection of data.

Pre-Experiment
To finalize the development of these two interaction techniques and remove any remaining drawback that may jeopardize the experiment, a pre-experiment has been performed. This evaluation includes a document-based usability evaluation with ergonomic criteria [3] followed by a user testing. This evaluation is limited to the application displaying the pictures, the interaction techniques and the experimental constraints embedded in the application to support the part of the experiment related to the target acquisition tasks.

The document-based inspection reveals a set of 12 problems mainly about legibility of target, prompting (e.g. progress in the tasks sequence), Grouping / Distinguishing by Format (e.g. inadequate use of colour to distinguish targets from other pictures), Feedback, Explicit User Actions, Consistency. This inspection led to improvements of the two prototypes and avoided the major drawbacks indentified with this Usability Evaluation Method (UEM). These new versions improved the distinction of the targets, added a transparency to the Softstick representation and better distinguished its pointer. A progress bar was also added indicating to user how many acquisitions he had already performed and how many were left. These improvements led to reset a second set of interaction techniques, cleaned of major basic usability drawbacks and ready to be tested by users.

In addition, a user testing has been carried out to identify problems that can only be revealed at runtime. During this pre-test we were both interested in usability problems and experimental protocol dysfunctions. We adopted an incremental strategy to iteratively improve the application and the protocol. Nine users participated to this pre-experiment. All of them are daily computer users and have no view or audition impairments. They all completed the entire protocol including a training phase, targeting tasks, responses to standard questionnaires (e.g. SUS [9], some items of IBM CUSQ and SUMI were used) and in-house satisfaction questionnaires, interviews and debriefing. The average time to complete the entire protocol was 90 minutes per participant (SD = 10 minutes). This pre-experiment revealed different bug related to the logging functionality and the Softstick velocity control. Additionally we computed a SUS score for both interaction techniques: each of them scored 72.5 which is marginally acceptable according to [4]. We also noted a learning effect due to a training phase on a single difficulty index. Obviously, we fixed all the drawbacks identified iteratively along these 9 testing and we ended with an “experiment ready” version of the interaction techniques, Softstick and experimental protocol, described in the next section.

EXPERIMENT
As mentioned above, the goal of the experiment is to study two interaction techniques for large spaces navigation, based on the use of physical artefacts owned by the users. To study these interaction techniques we have adopted a composite approach, i.e. a multi-factors evaluation. Indeed we seek to measure the quality of the interaction techniques in terms of satisfaction and performance. Such an approach is in line with recent advances in HCI evaluation, which promote the place and importance of aspects, related to the user experience especially with advanced forms of interaction techniques.

Comparison in terms of satisfaction is based on evaluation resources similar to those used in the pre-experiment. Performance analysis is based on the time required to perform the task and completed by the use of the Fitts law [15]. Slightly modified [26], the Fitts’ law is adopted in many HCI works and states that the time needed to point a target of width W, at a distance D from the started position of the pointer can be predicted with the following relation where a and b are constants whose values are obtained by linear regression:
The setting and the hypothesis for these experiments are described in the following sections.

Goals and hypotheses
Two interaction techniques exploiting physicality of small artefacts have been developed to navigate into a large collection of pictures (Figure 4). However the type of techniques considered is not traditional; the place and role of the physicality multiply the amount of interaction facets, i.e. channels constituting the interaction, and interaction targets, i.e. entities involved in or supporting the interaction: this directly increases the amount of potential usability problems. As mentioned above, a multidimensional evaluation protocol is required to compare them.

In this context, a first goal is to study the applicability of a well known method in a specific context: the use of the Fitts’ law with mixed interaction techniques. The first hypothesis (H1) is that such a law is still applicable even for this new form of interaction technique and the second hypothesis (H2) is that Fitts’ law parameters will vary with the type of mixed interactive techniques considered.

Furthermore, a second goal is to compare the two proposed techniques in terms of user performance (on pointing tasks) and in terms of user satisfaction. The third hypothesis (H3) is that it is quicker to point on a tactile surface, because it is quite similar to the use of a mouse; in addition, the meticulous pointing supported by this technique may contribute to maximize the efficiency. Finally a fourth hypothesis (H4) is that it is preferred to manipulate the camera itself, because motions require less skill and therefore require less attention on the actions performed; in addition, such rough gestures may imply less learning efforts and therefore be more appropriate to public spaces.

Participants
Twenty users, thirteen men and seven women, have been involved in the study. The age range was 22 to 56 years (\(M = 33, SD = 10.3\)). They were all regular users of mouse and keyboard. Ten of them frequently used tactile screen.

Apparatus
The system was executed on a 2GHz Dual Core laptop computer with 2 Gb of RAM. A video projector displayed the task on a white wall. The projection area was 2x1.5 meters and participants were removed from 2.5 meters.

The experiment environment has been implemented with .NET using C# language. The video recognition used a 60 fps digital camcorder. Detection of the camera position was performed by the ARToolkit+ library [36]. An ARToolkit+ tag was therefore stuck on the camera. The tactile screen is the one of an UMPC (ASUS R2H 900 MHz with 1 Gb of RAM), providing a 7-inches tactile screen.

Communications between the UMPC and the experiment system were enabled thanks to the UPnP protocol.

\[
T = a + b \times log_2 \left( \frac{D}{W} + 1 \right)
\]

The setting and the hypothesis for these experiments are described in the following sections.

Figure 3: View of the overall setting (top), tangible (left) and tactile (right) techniques in use.

Task and stimuli
The task consisted in the selection of a picture on a 24x12 matrix of pictures (Figure 4). The picture to be selected was highlighted, and randomly computed so that it fits the constraints of a Fitts protocol (predefined set of variations in terms of size and distance). To select a target, the user had to move the Softstick onto the target and stop its motion. Participants were instructed to proceed as quickly and accurately as possible.

Figure 4: experiment software
Design
Repeated measures within-subject design was used. The independent variables were Input interaction technique (Tangible technique and Tactile technique), Target Width (12, 30 and 50 pixels) and Target Distance (150, 450 and 750 pixels). The nine distance and width combinations gave height indexes of difficulty ranging from 2 to 5.99.

Participants were randomly assigned to 2 groups of 10. In the first group, participants began with the Tangible technique and ended with the Tactile technique; the order was counterbalanced in the other group. For each technique condition, participants completed 9 blocks: one block consisted of a ratio distance/width condition and was presented in random order. For each ratio distance/width condition, participants performed 15 targets selection. In summary, the experiment design was:
- 20 participants ×
- 2 techniques ×
- 9 blocks of predefined ratio ×
- 15 target selections
- = 5400 trials

The dependant variable studied was the pointing time. Errors of pointing are not recorded: the target to reach remains the same until the participant successfully select the correct target.

Variables
In order to verify that both tested devices follow the Fitts’ law, we have recorded for each pointing task the width of the target to be reached and the distance between the starting position of the Softstick and the selected target. In addition, we recorded all Softstick movements on the screen and the event that occurs during the selection of target. We associate with each collected event the time that has passed since the beginning of the experiment.

RESULTS
Quantitative Measurements
This section presents the quantitative results computed by use of descriptive and inferential statistics (i.e. ANOVA).

Movement time
As a first analysis, we computed the mean time required to select a target is equal to 5434ms with the Tactile technique and to 5387ms with the Tangible technique. Regarding the time to select a target, there is no significant difference between the two techniques.

An analysis of this selection time according to the index of difficulty (ID), defined by the ratio distance / width, shows that, for an ID equals to 4, the selection time depends on the technique used: participants pointed the target in 4984.6ms with the Tangible technique whereas they performed the same task in 4617.7ms with the Tactile technique. This difference is significant \( F(1, 1213) = 5.71, p = 0.017 \). However, this effect has only been identified for the ID equal to 4. In all other cases (ID ranging from 2 to 6), no significant differences have been observed.

Similarly, we performed an analysis of the selection time according to the distance, and then according to the target’s size. As for the ID, there is no significant difference in the selection time between the two techniques. On the other hand, according to the target’s width differences between the techniques have been observed. For the target’s width equal to 50 pixels (i.e. the biggest one), participants were faster with Tactile technique \( F(1, 1783) = 6.91, p = 0.009 \), while they are faster with Tangible technique for the small targets. The difference on small targets is marginal \( (p<0.1) \).

These differences confirm our third hypothesis: it is more efficient to select with the Tactile technique i.e. a technique which anyone is used to manipulate since it is a common form of interaction technique. However, this analysis also reveals some unpredicted limitations: the use of the Tactile technique is less accurate than the Tangible technique to point at small targets. This unexpected result plays in favour of the use and development of Mixed and Tangible forms of interaction: indeed we can infer that once the users will be familiarised with this new form of interaction, they will be able to perform task as quickly as with a Tactile technique but in a more accurate way.

Fitts’ law Analysis
A second part of the analysis consisted in computing the mean time required to perform a selection for a given ID. In Figure 5, X-Axis and Y-axis respectively represent the index of difficulty (ID, in bits), and the mean time computed over the participants for this ID (in seconds). Solid and dashed lines are the regression lines respectively obtained with Tangible techniques \( MT = 89.9 + 1371.1 \times ID \) with \( r^2 = 0.90 \) and the Tactile technique \( MT = -862 + 1617 \times ID \) with \( r^2 = 0.90 \).

![Figure 5: linear regression MT vs ID](image-url)
This first analysis shows two problems: 1) the correlation between Index of difficulty and Movement Time for both techniques is rather poor ($r^2=0.9$). The scatter plot reveals that the mean movement time is above the regression line for IDs whose width of target equals 12 pixels (the smallest target); 2) the Fitts’ law intercept $a$ is negative for Tactile technique. This negative value can be due to noise in data [37]: when the user misses the target, he must continue his pointing while he achieves it. These errors are more frequent for the smallest targets (and thus the highest IDs). This noise may explain points above the regression line and consequently a high slope and thus a negative intercept.

In order to verify if the target with the width equal to 12 pixels is a problem for regression analysis, we calculated regression equation without the ID of the pointing task where the width of target equals 12 pixels (Figure 6). Regression equations are $MT = 1050.1 + 984.1 \times ID$ with $r^2 = 0.997$ for the Tangible technique and $MT = 531.4 + 1085.5 \times ID$ with $r^2 = 0.981$ for the Tactile technique. Without the small target, there is a high correlation between MT and ID for both techniques. So, 12 pixels are too small for the width of a target.

![Figure 6: linear regression MT vs ID without targets whose width equal 12 pixels](image)

In both cases (with and without target with W=12), the profile of the computed regression lines is similar: they intersect and the one corresponding to the Tangible interaction is above the other for lower ID. In concrete terms, the regression lines intersect at an index of difficulty (ID=3.87 in Figure 5 and ID=5.11 in Figure 6). This intersection means that the Tactile technique is better suited for pointing task than the Tangible technique, if the pointing task is easy (ID<4). Inversely, the Tangible technique is more efficient than the Tactile technique for the harder pointing task (ID > 5). This analysis thus confirms the one made in the previous section: easy pointing tasks correspond to large target and/or reduced distance and hard pointing tasks are obtained with long distance and small target.

Furthermore, this analysis demonstrates that the Fitts Law still applies with mixed interactive techniques, i.e. interactive techniques based on the manipulation of physical artefacts. Our first hypothesis is thus verified. Regarding the second hypothesis, we also established that the parameters of the Fitts law ($a$ and $b$) also vary with the kind of physical actions a user has to perform with elements constituting the mixed interaction technique.

For example, a lower value of the $b$ parameter, such as with the Tangible technique, indicates a lower sensibility to the difficulty of the task to perform. In the present case, this may be linked to the resolution of the input interaction space: with the Tangible technique, required users’ motions are wider than those he has to perform with the stylus on the tactile screen.

Alternatively, having a higher value of the $a$ parameter, such as the Tangible technique in comparison to the Tactile technique, means that even for very simple task, the time to perform the task will be longer. In the present case, this may be linked with the fact the user first has to perform a large motion with the camera to bring the pointer of the Softstick over the threshold triggering Softstick motions. This analysis may therefore suggest reducing the size of the ineffective physical area of manipulation of the camera until an appropriate minimum time is reached for simple task, or in comparison to another interaction technique.

However, further work will be required to enable a finer correlation between the Fitts parameters values and the mixed interaction characteristics.

**Users’ preference and satisfaction**

As previously mentioned different questionnaires and interviews have been used to gather users’ preference and satisfaction. This section reports the major results collected through these evaluation techniques.

First we did not find major usability drawback about the Softstick and the application developed to support the targeting tasks. Interviews and specific questionnaires about the evaluation of the application and the Softstick only reveal few minor problems that could be solved easily. Therefore the results presented below will only focus on the interaction techniques.

**Questionnaires analysis**

We computed a SUS score to each IT: the Tactile technique scored 78.5 and the Tangible technique scored 77.5. The scores are better than the ones computed during the pre-experiment and are good and acceptable according to [4]. This measurement of control firstly indicates that usability of IT cannot jeopardize the results of pointing tasks. Secondly it reveals a marginal difference in favour of the
Tactile technique. The answers to the items of the IBM and SUMI questionnaires are consistent with the SUS ones. But it is still difficult to conclude on preferences or satisfaction only on the basis of SUS scores; we therefore further discuss it in the following paragraphs, on the basis of the analysis of post-experiment interviews.

Post-experiment interview analysis
We asked participants to indentify the three best and worst points of each IT. These questions are usually a fair indication of improvements, indicating what could be developed to reach a better usability level. Regarding the Tactile technique, the most frequent answers mentioned by the participants are:

- 3 best points (a) very usable, (b) easy to learn how to use it, (c) intuitive.
- 3 worst points (a) not precise enough, (b) awkward to control velocity of the Softstick, (c) the screen shapes limit the freedom of movement.

And regarding the Tangible technique, the most frequent answers mentioned by the participants are:

- 3 best points: (a) very usable, (b) easy to learn how to use it, (c) funny.
- 3 worst points: (a) less precise to point smaller pictures, (b) not easy to stay in the interaction area (i.e. in the camera field of view), (c) the size of the tangible camera is too big.

These qualitative results highlight one main difference about the best points: Tangible technique is mainly perceived as funny and the Tactile technique as intuitive. Regarding the worst points, it reveals on one hand that the Tangible technique may need to be more concrete and reliable: this seems to be technically easy to address through the use of a more accurate localisation system. On the other hand the Tactile technique shows bad points linked to the screen small size and definition. Consequently, these points cannot be solved without a radical change of IT including a bigger definition and size of the interaction surface.

About the users preferences between the two IT the answer show that 65% of participants prefer to use the Tangible technique. 55% of participants estimate that the Tangible technique is more usable than Tactile technique. On the same line, 60% of participants estimate that the Tactile technique is more constraining in terms of freedom of movement.

To conclude we can say that our fourth hypothesis (H4) is confirmed. Overall the users prefer use the Tangible technique because it offers a stronger freedom of movement.

CONCLUSION AND FUTURE WORK
Our work aims at exploring new interaction techniques using a small input device to interact with a collection of pictures displayed on a large output space. Our approach consists in exploiting two complementary dimensions of the physicality of a personal digital camera: on one hand, the object itself and its position in the space is used as a support for the interaction; on the other hand, users can take advantage of the interaction with the tactile screen of the camera. Moreover, we carried out an iterative design, which involved a pre-experiment to help us identify the main usability problems and resolve them before the user experiment.

Resulting interaction techniques have then been assessed in a users experiment. Different aspects of their use have been considered: user’s performance, preference and satisfaction.

The user’s performance is based on standard measures (like mean time) and revealed that the Tactile technique is more efficient than the Tangible technique for easy pointing tasks, while Tangible technique is better for hardest pointing tasks. To complement the analysis in terms of users’ performance, this work also intended to study the applicability of the Fitts law in the context of advanced interaction techniques. Results of this users experiment allow concluding that the correlation with Fitts’ law is established, despite problems due to pointing at the smallest targets. Having shown in this work that Fitts’ law applies to the designed techniques, it opens up a new research avenue that aims at predicting performances of mixed interactive techniques. To do that, we envision in a near future to further explore the different characteristics of our techniques to establish links between the parameters of Fitts’ law and the characteristics of our technique (including the physicality involved in MIS).

The study was conducted in a laboratory and proposed an abstract context of use. Moreover, only 20 persons have been involved in the experience. This is sufficient for an exploratory study, but may represent a limit for the results. Finally, the study is based on prototypes and should be replicated with more practical and technically reliable applications.

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