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Maudeline Marlier

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Tangible Interactions for Railway Management in Control Centres

Interactions Tangibles pour l'Exploitation Ferroviaire dans les Centres Opérationnels

MAUDELINE MARLIER, SNCF, DTIPG, Inria et LaBRI (University of Bordeaux, CNRS, Bordeaux-INP), France

With the growth of data and digital tools, the development of artificial intelligence in control centres and the goal of increasing train traffic, the role of humans will evolve. Today, operators are responsible for monitoring and managing railway traffic. Especially during incidents, where operators with different expertise need to collaborate to make decisions. The goal of this thesis is to test if tangible interactions can help operators in decision-making during incidents. For that, we conducted an in-the-field study to observe how operators work and collaborate, especially in incident scenarios, and identify the limits of the current approaches. To test our hypothesis, we did a formative study by developing a prototype to investigate the use of actuated tangible tokens on a tabletop to visualise and collaboratively explore different solutions to resolve incidents. Our results suggest that actuated tangible tokens are promising for collaboration, allowing the addition of information with a simple gesture and understanding easily through movements on the table. Future work will measure the impact of actuated tangible interactions on a focused attention task. An initial study will show whether actuated tangible tokens reduce inattention blindness compared with a simple projection on the table. Then, we will go further and compare actuated tangible tokens and projection during a remote collaboration task.

Avec l'augmentation des quantités de données et des outils numériques, le développement de l'intelligence artificielle et l'objectif d'augmenter le trafic ferroviaire, le rôle de l'humain va évoluer. Aujourd'hui, les opérateurs gèrent le trafic ferroviaire. En particulier lors d'incidents, ces opérateurs, avec différentes compétences, doivent collaborer. L'objectif de cette thèse est de tester si les interactions tangibles peuvent aider les opérateurs à prendre des décisions lors d'incidents. Pour cela, nous avons mené une étude sur le terrain afin d'observer comment les opérateurs travaillent et collaborent et d'identifier les limites des approches actuelles. Pour tester notre hypothèse, nous avons réalisé une étude formative en développant un prototype pour étudier l'utilisation de objets tangibles motorisés sur une table. Cela dans l'objectif de visualiser et d'explorer différentes solutions pour résoudre les incidents. Nos résultats suggèrent que ces objets tangibles motorisés sont prometteurs pour la collaboration, car ils permettent d'ajouter des informations d'un simple geste et de comprendre facilement la situation avec les mouvements des objets sur la table. Les travaux futurs mesureront l'impact des interactions tangibles motorisées dans le cadre d'une tâche d'attention ciblée. Une première étude montrera si ces objets réduisent la cécité d'inattention par rapport à une simple projection sur la table. Ensuite, nous irons plus loin et comparerons l'utilisation de ces objets par rapport à de la projection unique au cours d'une tâche de collaboration à distance.

CCS Concepts: • **Human-centered computing** → **HCI theory, concepts and models**; *Pointing*; Visualization techniques.

Additional Key Words and Phrases: Collaboration, Crisis, Actuated tangible interactions, Control centres

Mots Clés et Phrases Supplémentaires: Collaboration, Crises, Interactions tangible, Centres de contrôle

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1 INTRODUCTION

In France, railway traffic is monitored and managed by operators in control centres. During disruptions, operators must minimise the repercussions on the entire traffic flow and ensure quicker response times to inform passengers. However,

incident management currently requires operators to take time to understand the situation, to have an overall view of the traffic and its particularities at a given moment in order to be able to make a decision. Our research hypothesis in this thesis is that integrating a table in the centre of the room with tangible tokens could help operators in decision-making by improving collaboration, communication and resolution solutions visualisation.

Ishii and Ulmer [15] define the Tangible User Interface (TUI) as an interface that "gives physical form to digital information, employing physical artefacts both as representations and controls for computational media". Tangible interactions assist in structuring spatial information for verbal expression, contribute to conceptualise a verbal message thanks to gestures that play a key role in cognitive activity [1] and help when communication is difficult with words [5]. Tangible interactions have been also studied specifically with multi-user collaboration [2, 3, 6, 8, 11] or collaborative visual analysis [7] on large display, horizontal or vertical. When modelling events and simulate situations, TUI seems to have a remarkable effect on engagement during collaborative decision-making task [9]. Specifically, they can facilitate an understanding of complex systems while supporting collaboration [13].

In this paper, we summarize our methodology. We first present our result of visits to control centres, then detail our prototype before proposing future work about tangible tokens as output.

2 CONTROL CENTRES: FIELD STUDY

The French national railway company manage several types of control centres. In this paper, we will focus on train line centres supervising the journey of the trains belonging to the company. In order to understand how control centres could perform better, we visited 7 different control centres in Paris and Bordeaux. We summarised the roles into three specific positions: (i) Human and material resources management, they are in charge of the management of the resources which consist mainly of staff (train manager¹ and drivers) and of trainsets². (ii) Real-time information, they are responsible for implementing support measures for passengers and disseminating information to them. (iii) Global supervision and decision-making, they are in charge of the overall monitoring of the traffic and its perturbation and of coordinating the work of the two other positions, but also of the communication with the other control centres. These three roles are complementary and essential to the daily operations as well as the management of large incidents.

Most of our visits lasted more than three hours during which we observed the different operators and followed a semi-structural interview process. These allowed us to understand better how they are organised and how operators manage both routine operations and critical events. No control centre is identical, however, as a general rule, the control room is set up as a desk with multiple screens per operator (ranging from 6 to 8), equipped with mice, keyboards, and telephones. We observed that during an incident, operators are tasked with adjusting services, devising alternative strategies, coordinating resource availability and informing passengers. All of these while still monitoring the traffic on the rest of the network. For that, operators must possess a comprehensive grasp of the network's conditions at all times, along with a high level of situational awareness. With the current tools, information is scattered across all tools or in operator's head if they received a call for example. Information is not shared with the entire room and it can be difficult to get an overall picture. Operators are forced to store information in their working memory and to mobilise cognitive resources for mental representations. This leads to a slowdown in decision-making and limits collaboration.

With all these observations, we concluded that operators have some difficulties sharing information or maintaining an appropriate level of awareness of the situation when disruption happens on the network.

¹A train manager is responsible for comfort, safety and information for travellers on board and in train stations

²A trainset consist of a locomotive and carriages coupled together to form a unified set of equipment.

3 PROTOTYPING TANGIBLE INTERACTIONS FOR DECISION-MAKING IN CONTROL CENTRES

Inspired by projects proposing tangible interactions on shared screens for collaboration [12], we explored a solution that takes benefits from both a shared display and physical objects that can be manipulated. The goal is to leverage collaboration and situation awareness, while also harnessing the strengths of digital systems (look at data from previous incidents, add artificial intelligence to suggest solutions to resolve an incident or to compare several solutions) to address the limitations mentioned earlier. For that, we propose to explore the use of a digital tabletop with actuated tangible tokens (i.e. tokens that can move by themselves on the table and be moved by operators) as a tool for railway control, illustrated in Figure 1 (left).

We decided to use actuated tangible tokens to allow the system to show a potential solution to the operators. But also to provide an easy way to replay any alternative ones previously proposed. Operators can also add a new solution using the token or place two tokens next to each other to compare two solutions. To demonstrate a concrete use of our prototype, we draw up a scenario inspired by a real event with an incident-management expert. This, to allow operators to project themselves into the use of such a tool with a situation they have already experienced or could have experienced (real stations, real train numbers and realistic solutions). In this scenario, a train is stopped in the middle of the tracks between two stations. The operator can double-tap on the token that will then demonstrate on the network the visualisation of the solution, illustrated in Figure 1 (right).

As such a system would represent an important change in operators' work environment and work method. We wanted to first assess their acceptance of the use of actuated tangible interactions and explore with them how it could be integrated with their current practices and setup. Therefore, we developed a prototype and performed expert feedback sessions with 37 operators including 34 in a control centre in charge of the high-speed trains in the west of France and three crisis management experts. Our results suggest that such a technology could help operators during crises with information sharing, context understanding and time-saving.

4 ACTUATED TANGIBLE TOKENS AS OUTPUT FOR COLLABORATION

After this first experiment, we believe that actuated tangible tokens on a table could help operators to understand the situation but also to collaborate more closely. As explained before, operators need to maintain an appropriate level of awareness of the situation when disruptions happen on the network. For that, they need to stay informed and prevent new information as a new incident or available driver. They also need to know about their colleagues' activities and decisions. Several times, operators missed information because they did not see the app notification or did not hear oral information. In addition, to enabling dialogue with the system as shown in our prototype above, we have formulated the hypothesis that actuated tangible tokens for feedback during incident management could be better than current visual information on screen for operators to see what others are doing in other control centres or to see a notification of new information to take into account. This phenomenon in control centres is called "inattention blindness". It occurs when an individual is blind to the presence of an entire object while performing a distracting task [4] as in the well-known "gorilla in the room" experiment. Previous works test inattention blindness on screen [10, 14] but to our knowledge, no paper describes these phenomena with tangible objects moving on a tabletop.

In order to test our hypothesis, we will conduct two experiments: (i) With an abstract task, we will compare inattention blindness with actuated tangible tokens and with visual-only feedback both on a table with a single user. We are expecting that the tokens will be more noticed than the visual representation. (ii) If we find an interest in actuated tangible tokens, we will create a more specific task for remote collaboration. Two participants will use their

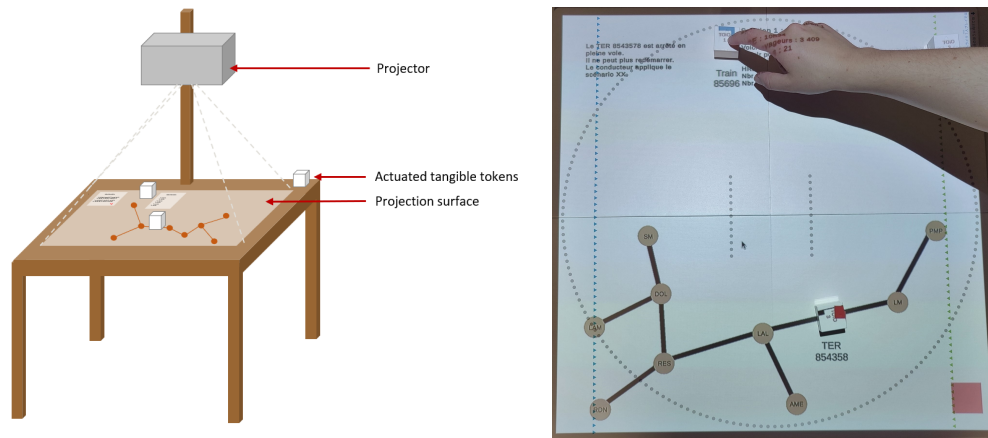


Fig. 1. (left) Schema of the setup of the prototype that we implemented composed of a projector (for top-down projection) and actuated tangible tokens able to roll on a table. (right) Photographs of an interaction on the prototype: operators double taps on the token to play the solution

own tangible device (a table with a projector and tangible tokens like the previous prototype). To cooperate, they will have verbal communication and tokens. To compare actuated tangible tokens and visual feedback we will create two different ways to communicate apart from verbal communication. For the first one, each participant will have one token on their table to interact with the system and other's actions will be visually represented on the table. In the second case, each participant will have two tokens on their table: one to interact with the system and another one on the table that will represent the other's actions. We have not decided yet about what will be "other's actions", it could be movement with their token, something they just validated or information sharing. The tasks and measures for both experiments have yet to be defined.

5 CONCLUSION

Tangible interactions have been used in different domains, but have not been studied in incident management situations for railway traffic. This thesis aims to study these human-machine interactions, taking a global approach by creating a prototype and then studying more specifically actuated tangible tokens for remote collaboration.

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