

Vispol: An Interactive Tabletop Graph Visualization for the Police

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Abstract

Vispol (Visualization for the police) is an interactive graph-based visualization that supports the work of the police of Hessen, Germany. A Vispol graph visualizes involved persons and their relations in crisis incidents like hostage takings or bank hold-ups. It presents a tabletop-based multi-touch and tangible user interface for the structured creation and manipulation of node-link diagrams. For instance, persons can be stamped into a graph with a stamp tangible object and links can be established employing multi-touch gestures. The graph can be visually filtered by applying layout algorithms via layout tangibles or by using a tangible magnet metaphor. We presented Vispol to the police to gather qualitative feedback. The police appreciated the visualization and generally liked the approach to use a multi-touch and tangible user interface. However, when it came to interacting with the tabletop system, police officers acted very cautiously and hesitatingly, as they were afraid of the new technology.

1 Introduction

In this paper we present the interactive graph visualization software Vispol (Visualization for the police) for interactive tabletop systems that supports the police work for the coordination of crisis incidents in control room facilities. Vispol allows creating node-link diagrams of persons that are involved in a crisis incident like a bank hold-up or a hostage taking. Vispol provides multiple benefits for the police: It allows police officers to visualize and analyze personal constellations of situations that are often confusing, enables to explain the constellation to persons that are new to the incident and offers a structured approach how gradually investigated information about an incident can be collected. Its tangible user interface allows for a playful approach to visually filter and arrange diagrams in order to answer simple questions like “Which persons stay at which location?” or “Which male persons carry a gun?”.

So far, to visualize and collect such information, the police of Hessen employed a whiteboard- and paper-based approach (see Figure 1), which corresponds with the results of a study of the use of paper-flight strips in air traffic control conducted by (MacKay 1999): For safety-critical applications, there might be many good reasons to automate existing work practices. However, automation would alter fundamental aspects of what users do and value and thus encounter resistance. Thus, Mackay recommends to introduce computer-based systems in a domain that has formerly accomplished in a manual, paper-based way, it is best to not use mice and keyboards but to consider alternative output devices. (Cohen and McGee 2004) are more precise in which kind of interfaces to use for safety-critical applications and recommend employing tangible multi-modal interfaces that make use of interaction familiar to users. Employing such post-WIMP user interfaces that employ interactive visualizations on a tabletop system in control facilities seems to be a promising combination (Forbus et al 2003), (Song et al 2009): Such a system can be easily installed in the facilities, allows multiple users to gather around the tabletop, discuss visualizations displayed on the tabletop and interact via multi-touch and tangible interaction without the need to share a mouse. Therefore, after thorough analysis of the police work, we decided to use a visualization approach in combination with direct touch and tangible interaction on a tabletop system.

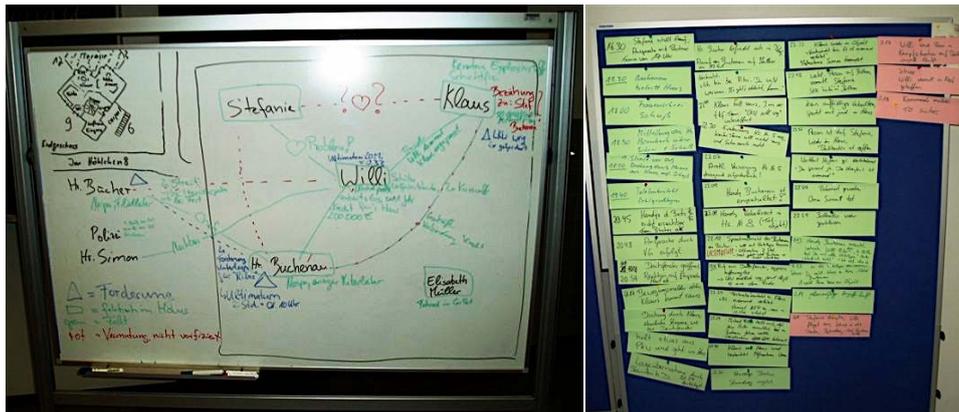


Figure 1: (left) Currently, the German police of Hessen draws information about persons and objects that are involved in a crisis situation on a whiteboard. (right) Additional textual information is collected with notes on a pin board.

This paper contributes a design study how interactive tabletop systems and visualizations can be employed in police work and which factors regarding visual design, interaction and collaboration are important for police officers. We examined a real-life scenario in the field of police work and meticulously conceived, designed and developed a user interface design approach in close collaboration with the police. Finally, we provide feedback results on the part of police officers that provide an opinion about Vispol and the use of post-WIMP interfaces in the vicinity of safety-critical applications. Additionally, we provide previously unseen tangible interaction metaphors with node-link-diagrams.

This paper is organized as follows. At first we summarize related work in section 2. We then describe the police work throughout crisis situations and the deduced concept, design, visualization and interaction of Vispol in section 3. In section 4 we describe the police's feedback. Finally, section 5 gives a conclusion.

2 Related Work

Vispol combines aspects of different fields. Firstly, it uses node-link diagram visualizations to display personal constellations used for criminal analysis. Using node-link diagrams to analyze the topology of criminal and terrorist networks can be found throughout the literature, e.g., in (Chen et al 2005), (Oatley et al 2005) and (Xu and Shen 2005). However, such diagrams are usually not employed to assist in command centers to structurally collect and visualize investigation results in real-time.

Secondly, Vispol allows for direct touch interaction to create and explore its diagrams. Exploration techniques can be found for instance in (Schmidt et al 2010). They present a set of multi-touch interaction techniques for the exploration of node-link diagrams. However, they focus on exploration and not on the structured creation of graphs. Although (Frisch et al 2011) present a comprehensive collection and evaluation of direct touch node-link diagram interaction techniques via multi-touch and pen interaction, they do not discuss the use of tangible UIs for content filtering. (Jetter et al 2011) combine tangible and multi-touch UIs to filter data on tabletops. However, they do not use it to visually filter graph data.

Vispol is a safety critical application that uses a direct touch and tangible user interface to create and analyze a crisis incident. A related user interface can, e.g., be found in the "nuSketch Battlespace" by (Forbus et al 2003). In nuSketch, military officers employ a sketching technique to create attack plans in a multimodal interface. The Incident Command System (ICS) by (Song et al 2009) investigates whether a sketch or drag-and-drop technique is suited better in a pen-based interface to coordinate incidents. Operators can sketch incidents on a map in a tabletop interface after an emergency call arrived in a command center. Although the nuSketch visualization and the ICS scenario take place in the vicinity of safety-critical applications and allow creating visualizations of incidents, both employ maps rather than graphs for visualization purposes.

3 Vispol

In this section we present our interactive graph visualization software Vispol for interactive tabletop systems. In section 3.1, we describe police work during crisis incidents. Based on this analysis, we have conceived the visualization concept described in section 3.2. Section 3.3 presents Vispol's direct touch and tangible user interface.

3.1 Police Work in a Crisis Incident

To figure out the requirements for Vispol, we visited the dedicated control room equipped with specialized hard- and software from which the police deal with a crisis incident. Additionally, we conducted a series of interviews with police officers and had access to detailed documentation material that describes the guidelines describing the procedures in such an incident.

Police officers involved in the management of a crisis situation are assigned to special tasks that differ from their usual work. The police leadership guides the investigations and decides about which actions the police perform on-site of the incident. Further police officers perform the actual investigations. Two police officers collect the investigation results and enter it into a server-based application for documentation purposes. As many different police officers perform the investigation work, it is necessary to exchange information between them. To provide an overview of an incident, the police officers that enter the information into the computer write aspects that they find noteworthy on memo cards and put them on a pin board in the control room (see Figure 1 on the right). Furthermore, they draw information about persons that are involved into the crisis incident on a whiteboard. Again, it depends on those two police officers, which information they find important enough to be sketched on the whiteboard. The memos on the pin board as well as the sketches on the whiteboard are used by the leadership to visualize the current situation of the incident. However, this approach has two severe drawbacks:

- Limited room to sketch the situation is available (in Figure 1 only five persons and their attributes fit on the whiteboard). Such a sketched incident can get quickly confusing.
- Police officers may draw whatever they find noteworthy on the whiteboard. Thus, they might draw irrelevant information and forget to add crucial information.

3.2 Visualization

3.2.1 Concept

It has been observed in the past, for instance, in (Cohen and McGee 2004) or (MacKay 1999) that computer interfaces for safety critical applications should incorporate existing work practice where possible. Therefore, Vispol adopts the current node-link diagram sketching approach in order that police officers can create the same diagrams with the help of a user interface.

Basically, Vispol visualizes persons and their connections to each other (see Figure 4, left). It allows for the incremental collection of investigated information about the persons. However, in contrast to the current investigation approach introduced in section 3.1, Vispol distinguishes between necessary and optional investigation results. Although the visualization offers to collect a multitude of important information, it should still present an overview of the fundamental persons and relations of the situation.

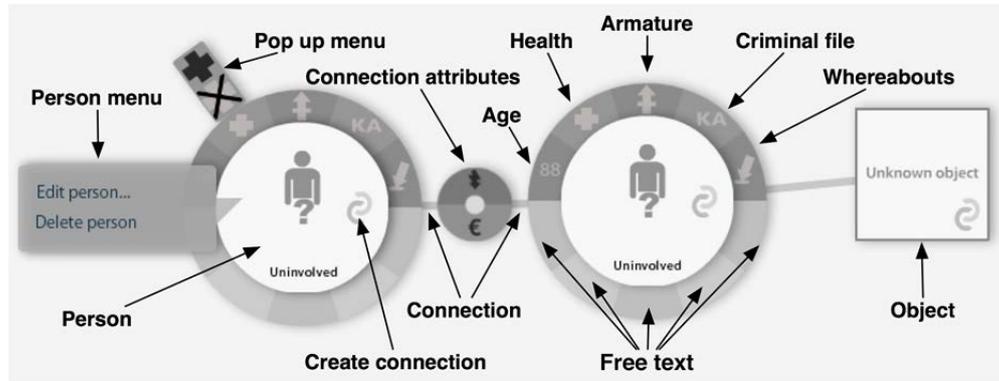


Figure 2: UI Elements in Vispol

Although there is no crisis incident like the other, we elicited in conversations with the police that some crucial attributes must always be investigated like the name, gender, age and current whereabouts of the person. Additionally, the police needs to know about a few other aspects:

- Does a person suffer from serious health conditions, for instance, if a person has cardiac problems or is pregnant?
- Is a person armed or not and if the person is armed what kind of weapon do they have?
- Does a person have a criminal file or not?
- The police wants to categorize people as culprits, victims or uninvolved.

To allow for the uniqueness of each crisis incident, free text can be added to every person. However, free text is either categorized as important information (like “person is trained in close combat”) or an important question that has to be solved throughout investigation work.

In addition to person nodes, an additional node type represents objects like cars. Two persons or objects can be connected with each other and the connection can be categorized to combine any of the following attributes: emotional (for instance, friends or lovers), business, crisis and family.

3.2.2 Design

The police explicitly wished, that the interface looked as neutral as possible. Hence, the employed colors are mainly black, white and grey. However, color has been used to highlight important aspects. Circles represent persons (see Figure 2). The crucial attributes of the persons that have to be investigated throughout investigation work are arranged in the five wedges of the upper half of the circle. In the lower five wedges, free text information can be stored categorized either as important aspect or as important question. The name and the category of a person are shown in the middle of the circle (see Figure 2). A person’s category

and gender is indicated with a pictogram in the middle of the circle. Objects are represented by grey squares. The object name is shown in the middle of the object.

Vispol's UI uses symbols in order to visualize a person's aspects. Paying tribute to the police's wishes, the employed symbols incorporate the official police symbols where applicable (for instance, the armature icon is a grey arrow pointing upwards with a horizontal dash). However, own symbols are employed where there was not an appropriate official symbol. Basically, if no information has been entered into a wedge, its symbol will be grey (in Figure 2 no information has been entered into the persons). A grey symbol indicates that necessary information has still to be investigated.



Figure 3: The whereabouts layout sorts nodes according to the place where a person or object remains (left). The type Layouts sorts nodes according to their types (right).

3.2.3 Layouts

Layout algorithms visually arrange nodes automatically. The circle view layout simply orders nodes in a circular fashion to show all nodes at once in an overview. Such a layout is especially handy, as Vispol offers pan & zoom interaction metaphors and nodes can easily end up out of the visible area. Applying the circle layout resets the zoom level and brings back all nodes to the center.

The whereabouts and the type layout (see Figure 3) evaluate the collected investigation data and serve to answer simple questions: The whereabouts layout tells the officers where persons and objects remain. The algorithm subdivides the tabletop surface into rectangular zones that correspond to the amount of whereabouts, which have been entered into nodes. In Figure 3 on the left, there are three whereabouts zones: To the left, the whereabouts are unknown. The persons and objects in the center zone stay at the “Feldstr. 20” and in the right zone at “Feldbergstr. 39a”. Similar to the whereabouts layout, the type layout subdivides the screen into rectangular type zones and arranges the appropriate nodes in them. In Figure 3 on the right, rectangular zones from left to right: uninvolved persons, culprits, victims and objects.

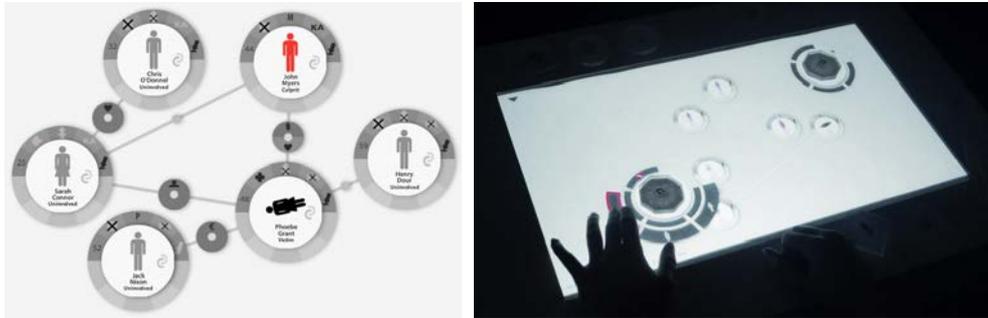


Figure 4: (left) A Vispol graph. (right) Magnet tangibles can be configured to attract nodes with certain aspects. Multiple magnet tangibles can be employed to create different fields in which nodes arrange according to their data.

3.3 Interaction

As Vispol should be accessible by all users in the control room, a typical workspace with a mouse and a keyboard would be impractical. Additionally, according to (Cohen and McGee 2004) or (MacKay 1999), it is promising to employ tangible user interfaces for safety critical applications, as users can perform familiar interaction. Although using an interactive whiteboard would have been promising, as the police have been using whiteboards so far, it would not have supported tangible UIs. Hence, interaction in Vispol is based on a direct multi-touch and tangible user interface in a tabletop setup. We describe the direct touch interaction in section 3.3.4 and the tangible user interface in section 3.3.5.

3.3.4 Direct Touch

To enter data, discuss or explore the visualization, police officers gather in front of the tabletop setup. A user arranges nodes by touching and dragging them and enters investigated data with popup menus and with a virtual keyboard. The whole visualization can be panned by dragging a finger on the visualization's background and zoomed by performing pinch and zoom gestures on the background. To create a connection between nodes, a connection line can be dragged out of the "Create connection" symbol (see Figure 2) onto another node. To support experienced users, we employ a metaphor also reported in (Frisch et al 2011). Tapping two connection symbols at once creates a connection via multi-touch.

3.3.5 Tangible User Interface

Vispol supports a tangible user interface to provide a simple access to complex functionality: By putting the appropriate physical object on the surface, the according functionality will be triggered. In Vispol, a widget appears around the tangibles when put on the surface. This widget gives a feedback about the state of the tangible (e.g., see Figure 5, left) or allow for the configuration of the tangible via touch (e.g., see Figure 4, left). In the following, we introduce the different tangible interaction metaphors of Vispol.

A person tangible (see Figure 5, right) allows stamping a new person into the visualization. Alternatively, by putting the person tangible on an existing person this person can be

selected. After stamping or selecting a person, rotating the tangible 45° clockwise (the tangible widget gives a visual cue about different interaction zones of the tangible) opens the person configuration dialog. If two or more person tangibles remain on the surface, moving these tangibles together creates a new connection.

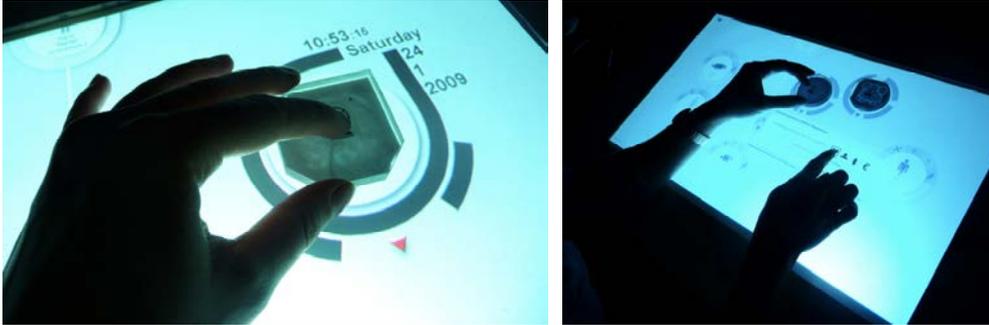


Figure 5: (left) The timestamp tangible saves or loads states of the Vispol. (right) The person tangible allows for stamping a new person into the visualization. Rotating the tangible to the right opens the configuration dialog for the new person. Moving together two person tangibles creates a new connection.

Timestamp tangibles (see Figure 5, left) allow creating save states of the visualization. The time of the timestamp is shown in the upper right corner of the tangible widget. If a timestamp has been created with one of the timestamp tangibles, putting the same tangible on the table sets the visualization to the saved state.

Magnet tangibles (see Figure 4, right) allow for creating generic magnets. A magnet tangible exerts a force that attracts all nodes that correspond to the magnet's configuration to gather around the tangible. The magnet widget enables the user to set the configuration. As filter criterion all values of a person can be selected. For instance, a user can configure a magnet that attracts male persons with an age between 20 and 35 years that carry a rifle. Putting two or more magnets on the surface causes nodes that are attracted by multiple magnets to gather between these magnets. Thus, magnets can be employed to visually filter the visualization.

To apply one of the layouts explained in section 3.2.3, a user can put the appropriate layout tangible on the surface to apply the layout to the visualization. As the arrangement of nodes in Vispol can be time-consuming, it has been especially important to the police that the state of a visualization previous to the application of a layout can be restored. Therefore, removing a layout tangible from the table restores the previous state. However, if a user wants to keep the applied layout, rotating the tangible more than 180° clockwise causes the layout to remain (the tangible widget gives an appropriate visual cue).

4 Feedback

To gather feedback, we presented Vispol on our multi-touch and tangible tabletop system Virttable that we carried to the police facilities. In a meeting room, nine police officers were

asked to try out the touch and tangible interaction in an informal setting and were interviewed afterwards. We presented Vispol's basic functionality on the Virttable and the officers were asked to try out a prepared demo scenario. Although at one point two officers tried to interact at once with Vispol, they mostly interacted alone with Vispol.

Overall, the feedback pertaining the visualization has been positive. The abstraction of persons, objects, connections and attributes were embraced. As we were told, usually the leadership of the German police (and therefore our target group) consists of male persons who are older than 50 years and have a quite conservative approach to technological innovations. Additionally, such officers are afraid of making "mistakes" while interacting with a user interface in front of others. Hence, although touch interaction had been known, officers interacted very hesitatingly and cautiously with Vispol. Mutual interaction had been completely new to the officers so that they tried to interact with Vispol alone. In one case an officer tried to interact with Vispol but was told by another officer not to change anything because he was afraid that the other user could destroy his arrangement (the actual words were "If he grabs into my arrangement, I will pull my gun."). Seeing and using a tangible user interface approach was completely new to the police officers and they rather regarded it as some kind of a toy (and a toy is not appropriate for real men to "work" with). However, a few brave officers tried out the tangible interaction metaphors and could easily use the provided functionality. Additionally, the officers told us to consider fastening the tangible objects to the tabletop system as even within the police vicinities loose objects would be likely to disappear. Regarding the hesitant approach of the police officers towards the tabletop interface, we were told that it is common knowledge within the police that new computer technologies are only accepted slowly. However, in the past there had been a successful approach to motivate users to adopt a new computer technology: When desktop computers had been introduced to police work in the early nineties, games had been installed to encourage police officers to use the computers and develop a positive attitude towards this technology. Thus, when introducing tabletop computing systems, it could be beneficial to provide software that alleviates the initial approach to the system for inexperienced users and create a positive attitude towards the new technology.

5 Conclusion and Future Work

Vispol presents an interactive information visualization with a multi-touch and tangible user interface in a real application context for safety critical applications that has been developed in cooperation with the police of the state of Hessen, Germany. Vispol allows creating node-link diagrams of persons that are involved in a crisis incident like a bank hold-up or a hostage taking in order to enable police leadership to keep an overview of a crisis incident. Additionally, Vispol allows introducing newcomers to an incident. Vispol presents interaction metaphors that allow for the playful creation, manipulation and exploration of node-link diagrams via multi-touch and tangible user interfaces. In a feedback conversation, the police embraces the visualization approach of Vispol. However, they are skeptical regarding the introduction of tabletop setups in the German police work. They doubt that

police officers are willing to actually adopt such new interaction techniques, as they are typically afraid of being embarrassed when making mistakes.

In future work we plan to install a tabletop system with Vispol in the control room facilities of the police and conduct a user study of Vispol throughout a training situation of a crisis incident.

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