Re-Collision:
A Collision Reconstruction Forensics Tabletop Interface

Marcel Tozser [1] **Nicole Sultanum**[1,2] **Ehud Sharlin** [1] **Ken Rutherford** [3] **Colin Foster** [3]
University of Calgary [1] IBM Research, Brazil [2] Calgary Police Service [3]
{mtozser, nbsultan, ehud}@ucalgary.ca {krutherford, pol4047}@calgarypolice.ca

ABSTRACT
In this paper we present the design, implementation and preliminary evaluation of *Re-Collision*, a prototype collision reconstruction tabletop interface. *Re-Collision* was developed through a participatory design process involving expert users from the Calgary Police Forensics Team and Collision Reconstruction Team. We briefly cover fundamental domain characteristics emerging from interview sessions and explain how these informed the design of *Re-Collision*. The paper details our current prototype implementation and discusses results of a design critique conducted with domain experts using our system, helping us assess the potential of tabletop interfaces as aids in the process of collision reconstruction, as well as delineate and discuss relevant design implications.

Author Keywords
Collision reconstruction; forensics; tabletops.

ACM Classification Keywords
H.5.2 [Information interfaces and presentation]: User Interfaces. - Graphical user interfaces.

INTRODUCTION
Among the many existing branches of police investigation, the field of collision reconstruction is focused on examining and solving traffic accidents, attempting to recreate vehicle crashes to find the sources and related circumstances of such events. Collision reconstruction shares many of the general characteristics of police work and forensics, such as involving critical decisions (both impact-wise, and time-wise), and requiring the processing of large amounts of evidence in a timely manner. However, unlike other sectors of police work, collision reconstruction received relatively little attention from the human-computer interaction community, leaving the idiosyncrasies of collision reconstruction practitioners generally unexplored from an HCI perspective, with little published insight on how to create and design better suited interfaces for this domain.

To fill this gap, as well as to guide design efforts for the creation of a domain-specific interface for collision reconstruction analysis, we sought feedback from experts at the Calgary Police Service (CPS), conducting interview sessions with the Collision Reconstruction team and the Forensics team. From these sessions we perceived, among other things, that the domain is potentially very collaborative, and relies heavily on spatiality with extensive usage of diagrams and schematics – characteristics for which tabletop interfaces can be particularly meaningful. We thus designed and developed a tabletop prototype system for collision reconstruction analysis, and conducted a preliminary design critique with the CPS domain experts to validate the design and the concept of tabletops to their work. We present our system and the study we conducted, and share the reflections and design implications which emerged from our evaluation.

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COLLISION RECONSTRUCTION
Collision reconstruction, a subfield of police work, relates to the investigation of traffic accidents and violent crashes through forensic science techniques, in order to understand how the event took place and what caused it. The workflow of collision reconstruction, as described by the CPS specialists, starts by *collecting evidence at the scene* (*e.g.* pictures, GPS location markups, witness reports, samples, and so on), which are *compiled and processed*. Then, evidence is *analyzed*, conclusions are drawn, and the case is prepared and *presented to court*. Among these, the *analysis* stage is arguably the most crucial one for collision reconstructionists. During this step, a top-down diagram of the scene is created, containing exact location of elements at the scene (e.g. vehicle, parts, victims, street posts, buildings), confirmed by precise GPS coordinates; car crash physics are taken into account, used to verify and simulate crash conditions. From our interviews, we found some of the fundamental characteristics of this process to include:

(I) Spatiality: Top-view diagrams describing the scene are an omnipresent element of the investigation, and denote the strong importance of spatial awareness.

(II) Emphasis on the facts: automatic simulations are sometimes used in-house to verify conjectures about a certain case. Nonetheless, a clear separation between the *consolidated facts* and the officers' *conjectures* (albeit strongly supported by data) is always clearly established, and only the factual layer (and what can be proven from it) is effectively brought to court for prosecution.

(III) Accuracy, with Efficiency: Police investigation often includes the processing of large volumes of evidence data. It also involves time-critical and impactful decision-making, while maintaining fair and prompt service to the citizens involved in the investigation. Therefore, it is essential to find

strategies to speed up analysis, while maintaining thoroughness.

(IV) Collaboration and group brainstorming: Although not necessarily present for all cases, investigation often becomes a collaborative process, with officers sharing insight and expertise to facilitate the task of analysis; one might see, in a typical session, white boards, diagrams and calculations being shared amongst experts for discussion and validation. Cooperation between investigators from different sectors might also occur.

From these four domain properties, we envisioned digital tabletops as notably suitable environments for collision reconstruction analysis, due to their inherent support of collaborative tasks and spatiality through direct, on-screen manipulation. Tabletops also naturally afford intuitive access to powerful automation, processing and storage, assets which are still often lacking in current police work practices. Our subsequent design efforts have focused on addressing these properties, and will be revisited in our system description.

RELATED WORK

A few off-the-shelf desktop tools are available to traffic accident reconstruction investigators for characterizing the crash scene. Mostly they feature top-view diagram creation tools containing scene description elements [11,12], while some also include 3D animation and crash simulation capabilities [1,10,14] . These tools are essentially WIMP-based desktop applications, targeted at the single-user scenario. Another spectrum of solutions focuses on supporting the overall experience and collaborative aspects of the police investigation analysis. For the traditional crime investigation and law enforcement, the work of Atzenbeck *et al.* [2] addresses team communication and collaborative analysis through the use of a spatial hypertext tool. Zhao *et al.* propose the integration of collaboration tools to a system they call COPLINK [4] – an IT system for crime investigation – focusing on both intra-agency [16] and interagency [15] cooperation. Studies have also been conducted for further understanding of the work and technology of police investigation from a user's perspective [3,6,9,16]. Nonetheless, to the best of our knowledge, our work is the first attempt to understand the forensics domain of collision reconstruction from a user perspective and focus on co-located collaborative analysis for the field.

Finally, there are a few instances of digital tabletops applied to peace and order civil service. Within command and control for emergency settings, tabletops were employed to time-critical decision making in orchestrating coordinated actions of several entities (including the police) [5], as well as a map-based emergency analysis system [13]. Recently, a more related instance within the police domain, Luderschmidt *et al.* [7] explore a graph-based interactive visualization on digital tabletops for traditional crime investigation; It covers, however, a very distinct class of police cases than the ones in this paper, not touch-basing on essential issues to collision reconstruction such as spatiality. Ultimately, we believe our work to be the first research effort attempting to apply interactive tabletops to the specificities of the collision reconstruction analysis.

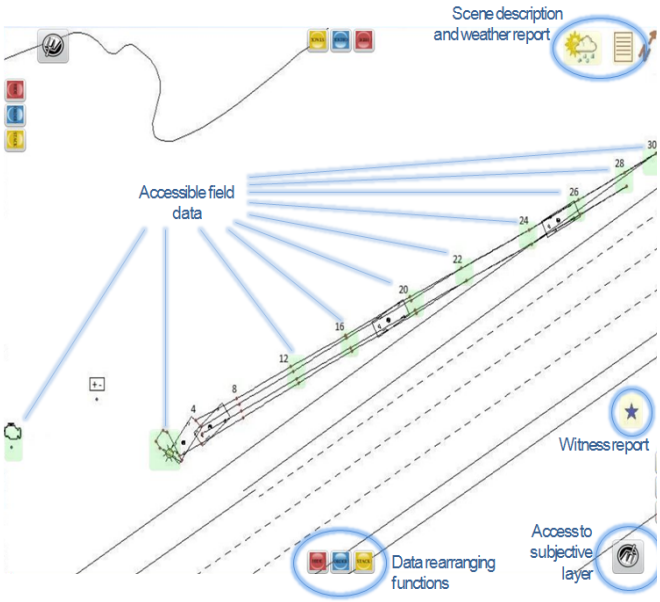


Figure 1. The main interface, featuring a schematic diagram depicting a car crash. Interface functions are indicated in blue.

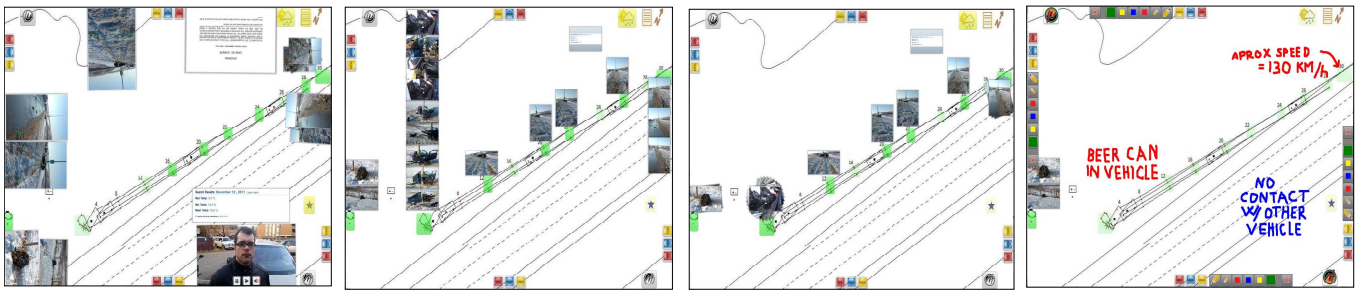
RE-COLLISION

Re-Collision – developed for the Microsoft Surface – was designed to aid traffic collision investigators with an interactive and collaborative tool on tabletop, attempting to approach the many domain aspects observed for the task of analysis, namely: *(I) spatiality, (II) fact/hypotheses awareness, (III) efficiency and (IV) collaboration*. The system was populated with real data, provided by the CPS.

Taking in consideration the strong separation to be made between factual data and hypotheses, our interface design encompasses two distinct layers: the *factual* and the *sandbox* layer.

The *factual layer*: visualizing the evidence

The main view of *Re-Collision* consists of a traffic accident scene diagram along with visual representations of data/evidence pertaining to a specific accident (Figure 1). Field data collected at the scene – pictures, reports, videos, and so on – usually have an associated location on the map. Related evidences are grouped and made accessible through localized, semi-transparent green highlights; it can then be accessed via touch tap, and can also be toggled to appear or disappear on demand – thus facilitating evidence filtering. Other non-spatial data might be available (such as a weather report or a general description of the scene) and these were associated to special toggleable icons on the diagram as well, for the sake of consistency. Once certain data/evidence is visible, it can be moved, rotated, and scaled through touch (Figure 2(a)).



(a) (b) (c) (d)

Figure 2. (a) elements from the scene are selected for display; (b) *Order* function organizes photos side-by-side, oriented towards the lower side of the screen; (c) *Stack* function organizes the pictures in piles, associated to their respective location; (d) the sandbox layer is activated.

Due to the large amount of media to analyze at a time, quick rearranging functions were included to efficiently organize evidence – *Hide*, *Order*, and *Stack* – with respective buttons placed on each edge of the screen for facilitated access to all users. *Hide* closes all open media; *Order* organizes all displayed data side by side, near their respective location while reorienting them towards the edge button that triggered the action (Figure 2(b)); and finally, *Stack* places the opened data near their location, in a fanned stack also oriented towards the triggered edge (Figure 2(c)).

The *sandbox layer*: reasoning and sense-making

The evidence can be visualized, moved, stacked and resized. However, it cannot (and should not) be altered in any way. Nonetheless, during analysis, there are occasions in which one needs to augment or annotate the presented data, or even add new tentative elements to aid the analysis. To address this need, we created the *sandbox* layer allowing for the scene and the evidence to be more freely explored in collaborative brainstorming exercises. For our initial implementation we adopted a "drawing pad" approach, following inspirations from our initial meetings with the CPS teams who informed that white boards were extensively used in time-sensitive investigations.

To access the sandbox layer, two "sandbox" buttons were placed on opposite corners of the interface -- placed away from the rearranging buttons for clarity. Upon touching either of them, the interface activates the sandbox mode, with sketching tools appearing beside each of the three data rearranging buttons. Tools include the option of four different colors, an eraser, and a *Clear All* function. Drawings (Figure 2(d)) can be made via direct touch.

DESIGN CRITIQUE AND REFLECTIONS

To evaluate the concept of tabletop interfaces for collision reconstruction and discuss shortcomings and potential improvements of *Re-Collision*, we conducted a focus group session with the CPS, including the same officers who participated in our initial meetings. After a short introduction to the functionalities and features of the interface, the participants were invited to freely interact with the tabletop and critique, pointing out limitations and suggesting improvements. The session was videotaped for later analysis. We discuss some of the highlights of this session, from a perspective of validation of tabletops for the domain as well as relevant directions to guide subsequent design efforts.

Tabletops for Awareness, Communication and Collaboration

One of the discussed benefits of the interface included facilitated communication between non-experts, or experts from different domains, as stated by a collision reconstruction investigator: *"I can see the benefit of being able to show the forensic interview team exactly what the information is"*. It was also highlighted that the facilitated access and handling of data through tabletops could contribute to a better understanding of particularly complex and data-intensive cases. A member of the forensic unit acknowledged, *"I believe that this type of interface would benefit in the more complex protracted investigations"* and also *"(...) the volumes of information and to be able to continually collaborate for two years, to have information continually added, and to have a tabletop such as this where you can access information from day 'one' would be beneficial"*. Finally, with the use of tabletops, we hoped to provide an inviting medium to stimulate user's contributions, and thus spark positive collaboration amongst investigators. During the session, although users were not asked to simulate an investigation, they were actively interacting and reasoning with the data as a group. We considered this particularly meaningful, given that the forensics and the collision reconstruction teams work on completely different sectors within the CPS. We believe the tabletop environment might have contributed to empower and stimulate users to partake in the discussion and the interaction experience.

Potentializing Analysis – Implications for design

The focus group also generated many ideas for improvement, which at the same time embody fundamental concerns to domain users – also well aligned with topics such as clutter, awareness and sense-making brought forward by Morris *et al.* [8]. We reflect upon them in the form of a preliminary list of design implications to guide future efforts. We believe our guidelines may apply to not only to collision reconstruction but also to other forensics tabletop applications and possibly analogous domains.

1. Effectively de-clutter the visualization space: we observed that the members seemed comfortable manipulating the data and showed no problems correlating the collision scene diagram areas and associated evidence. However, the limited amount of surface area quickly became evident, as soon as all users started manipulating photographs simultaneously, and each decided to drastically enlarge their set of photographs. We suggest taking into account strategies to facilitate parallel evidence fetching, as well as effective evidence management for a coherent and organized workspace. Suggested ideas also revolved around the idea of external personal spaces (*e.g.* tablets), for individual manipulation.

2. Facilitate efficient sense-making through information correlation: the experts stated the importance of strengthening connections amongst stored data, for instance through user-defined data links between related pieces of evidence: *e.g.* associating the appearance of a witness on a surveillance video to the document containing her official written testimonial alleging icy road conditions, which in turn links to the corresponding weather report at the occasion. Alternatives for search mechanisms were discussed, as useful resources for facilitating navigation and retrieval to enable analysis of larger volumes of data.

3. Provide evolution awareness on the case: the officers emphasized the importance of awareness of the temporal progression of the case: for example, being able to load a scene and browse it over time, seeing its evolution from the initial investigation stages to later conclusion. This exercise of past recollection is often employed when briefing external people into a case, and direct support to this would be very beneficial.

4. Supporting hypothesis creation and testing: much of the reasoning process the officers described for an investigation relies on the evaluation of hypotheses – e.g. "*Mr. X claims not to be able to see Mrs. Y driving from the adjacent road; Is this possible? Where could he be located at that time?*". The *Sandbox* layer — which in this prototype was limited to sketching — in essence could encompass any reasoning over the evidence data, as well as resources to support and assess this reasoning, such as user-defined potential vehicle trajectories associated to physically-based simulations to visualize and compare the several outcomes.

CONCLUSION

In this work, we investigated the use of tabletops applied to the domain of collision reconstruction, with a focus on *spatiality*, *emphasis on the facts*, *efficiency*, and *collaboration*. Our design approach involved the participation of expert officers from the CPS, from initial brainstorming stages to the various prototyping stages of Re-Collision, and the focus group evaluation which helped provide insight into domain aspects, assess the potential of tabletops for the field and reflect on a set of implications for design. We hope these initial research efforts will trigger a greater interest on the domain from an HCI perspective, which we believe would be extremely beneficial for both fields and of great impact to society.

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