A Novel System for Rapidly Identifying Toxic Chemicals

Suresh K. Bhavnani[1,2] **PhD, Arun Ganesan**[3], **Clayton Scott**[1,3] **PhD, Chris Weber**[4] **PhD, Paul Saxman**[2]
[1]Center for Computational Medicine & Biology, Medical School, [2]Michigan Institute for Clinical & Health Research, [3]Electrical Engineering & Computer Science Department, University of Michigan, Ann Arbor, MI; [4]Washtenaw County Hazardous Materials Response Team, Ann Arbor, MI

Abstract

First responders have a critical need for rapidly identifying toxic chemicals during emergencies. However, current systems such as WISER require a large number of inputs before a chemical can be identified. Here we present a novel system which significantly reduces the number of inputs required to identify a toxic chemical.

Introduction

The rapid and accurate identification of toxic chemicals is critical for saving lives in emergency situations ranging from terrorist attacks to chemical plant incidents. Unfortunately, current systems such as WISER (developed by the National Library of Medicine [NLM]) require a large number of inputs before a chemical can be identified [1]. This is because chemicals tend to have a high overlap of symptoms (e.g., irregular breathing) resulting in few that are discriminating. Furthermore, these systems use *Boolean Search* to access databases, and provide little assistance for determining which symptoms are the most discriminating. To address this problem, we designed and evaluated a novel system to help first responders rapidly identify toxic chemicals.

Design and Evaluation

We collaborated with an experienced first responder from a local county hazardous materials response team to iteratively design an algorithm and interface that addressed the high overlap of symptoms across chemicals. We then used guidelines (e.g., provide system feedback) from the *heuristic evaluation* method [2] to implement and refine the design.

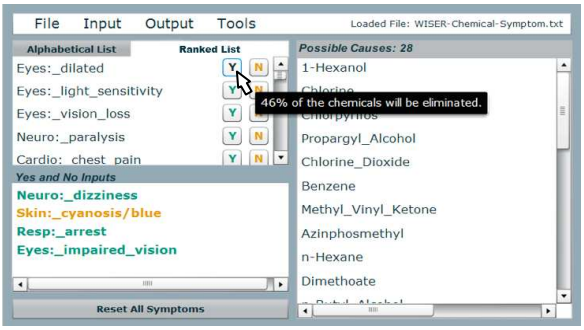

Figure 1. The prototype enables first responders to select from a list of symptoms (top left pane), ranked by their ability to distinguish between chemicals.

The above method resulted in a prototype which ranks the symptoms based on their ability to eliminate close to half of the remaining chemicals. For example, as shown in the upper left pane of Figure 1, the top-ranked symptom (*Eyes: Dilated*) will eliminate 46% of the chemicals (as shown by the pop-up box) if its yes option ("Y") is selected. Once a symptom is selected as "Y" or "N", it is moved to the lower left pane, the chemicals matching the inputted selections are displayed in the right pane, and the symptoms for the remaining chemicals are re-ranked in the top left pane.

System performance was evaluated by simulating a user diagnosing a chemical exposure using either WISER or our prototype. In each case, we calculated the smallest number of symptoms to uniquely identify each chemical, and averaged this number across all chemicals. For WISER, the smallest number of symptoms for each chemical was estimated by randomly sampling (without replacement) the symptoms of the chemical until it was uniquely identified; recording the number of symptoms needed; and averaging that number over 2000 repetitions of the above method. Similarly, we estimated the average number of symptoms to identify a chemical by using our prototype to select the symptoms. Significantly fewer symptoms were needed to uniquely identify a chemical using our prototype (mean=8.33, SD=0.7) compared to WISER (mean=25.69, SD=12.79, $p<.01$ two-tailed t-test).

Conclusion and Future Research

A demonstration and the source code for our prototype have been provided to the WISER team at NLM. We hypothesize that our approach should improve the rapid identification of toxic chemicals during emergencies. In our future research we plan to test that hypothesis through a comprehensive user study with first responders.

Acknowledgements

This study is funded by NIH grant # UL1RR024986.

References

1. Bhavnani, S.K., et al. Network Analysis of Toxic Chemicals and Symptoms: Implications for Designing First-Responder Systems. *Proc. of AMIA'07* (2007).
2. Nielsen, J. (1994). *Usability Engineering*. San Diego: Academic Press.