A Game for Studying Maintenance Alerts' Effectiveness (Extended Abstract)

Avraham Shvartzon, Amos Azaria and Sarit Kraus
Dept. of Computer Science
Bar-Ilan University
Ramat Gan 52900, Israel
{shvarta,sarit}@cs.biu.ac.il
azariaa@cs.cmu.edu

Claudia V. Goldman and Omer Tsimhoni
General Motors Advanced Technical Center
Herzliya 46725, Israel
{claudia.goldman, omer.tsimhoni}@gm.com

Joachim Meyer
Dept. of Industrial Engineering
Tel Aviv University
Ramat Aviv, Tel Aviv 69978, Israel
jmeyer@tau.ac.il

ABSTRACT

In this paper we present a space-ship game which allows us to evaluate human behavior with respect to maintenance and repairing malfunctions. We ran an experiment in which subjects played the space-ship game twice. In one of the games, they were simply told that they should perform maintenance every 20 seconds, and in the other game they received alerts from an agent for performing maintenance every 20 seconds. We show that when receiving alerts, people tented to perform more maintenance, and perform slightly better (not statistically significant). We suggest that in order to further improve the performance of the players in the space-ship game, one should also consider when to provide these alerts.

Categories and Subject Descriptors

I.2.m [**Computing Methodologies**]: ARTIFICIAL INTELLIGENCE—*Miscellaneous*

Keywords

Maintenance Optimization; Alert System; Computer Games

1. INTRODUCTION

In this paper, we present the *spaceship game*, which allows us to model and evaluate people's tendency to perform maintenance and repairs. In this game, a player controls a spaceship, which shoots asteroids (see Figure 1 for a screen-shot). The player must also retain enough fuel for the spaceship to function. The player is required to perform maintenance actions on his or her spaceship. Occasionally and depending on the frequency the player performs maintenance, the spaceship may suffer malfunctions with one of several levels of severity which require repair and may limit the spaceship's performance. We ran an experiment in which subjects played the space-ship game twice. In one of the games, they were simply told that they should perform maintenance every 20 seconds, and in the other game they actually received alerts for performing maintenance every 20 seconds. We show that when receiving alerts from an agent, people tended to perform more maintenance, and performed slightly better (not statistically significant).

Appears in: *Proceedings of the 14th International Conference on Autonomous Agents and Multiagent Systems (AAMAS 2015), Bordini, Elkind, Weiss, Yolum (eds.), May 4–8, 2015, Istanbul, Turkey.*

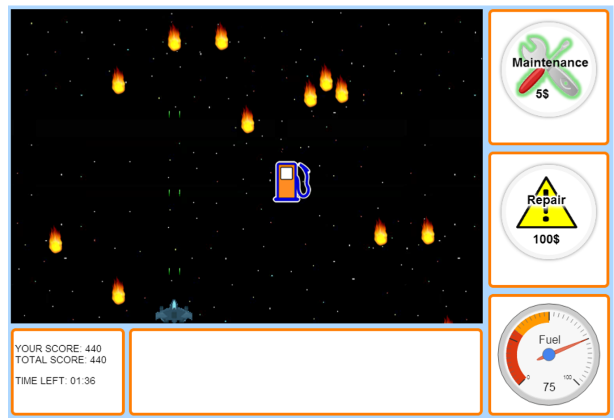

Figure 1: A screen-shot of the spaceship game in progress.

We attempt to build a smart agent which will take into account human behavior and provide alerts at better timings. Such an attempt should allow the agent to significantly improve the performance of the players in the space-ship game.

2. RELATED WORK

It is not always easy to modify the behavior of humans, since people often follow suboptimal decision strategies because of lack of knowledge of own preferences, the effects of the task complexity, framing effects, etc. There have been various attempts in the field of human-agent interaction to change or modify the behavior of humans in a way which would be favorable for the agent [3, 4, 10, 7, 2, 6, 5]. Although there exist many applications to help equipment owners maintain equipment, however, we are not aware of any study of such an alert system in this field. Studies do exist, however, in the field of medicine, in which patients are reminded to take their medicine [12].

Several studies have considered interruption management, asking about the best time to interrupt the user [1, 8]. Shrot et al. [11] clustered the users into groups and then used collaborative filtering in order to determine which interaction method would work best with each type of user. This approach yields different policies for different users. However, in contrast to this paper, they did not try to change the user's behavior, but convey information at the best timing. Huang et al. [9] suggest a maintenance model, which uses a form of personalization. The model utilizes collected data to inform a user about recommended tasks that needed to be performed.

3. THE SPACESHIP GAME

The characteristics of the spaceship game were motivated by the following real world maintenance characteristics:

1. Maintenance tasks that must be performed distract the user from performing his or her regular tasks.
2. Maintenance activities decrease the probability of faults, but equipment may still sometimes malfunction, even if it is well maintained.
3. The severity of faults increases if they are not repaired.
4. Maintenance tasks cost less than repair tasks.

In the spaceship game the player controls a spaceship (see Figure 1). Throughout the flight the spaceship should shoot down meteors which fly in space. Every time a meteor is shot down, the player gains money (points). The player must also avoid getting hit by the meteors and loses money when hit occurs. The spaceship has a fuel tank that diminishes over time, and the player needs to occasionally refill (with some monetary cost proportionate to the amount of fuel missing). The spaceship is refilled by contacting a gas station. If the spaceship runs out of fuel, it is automatically refilled by a refilling ship, however, such a refill is very expensive.

In order to reduce the probability of malfunctions, the spaceship needs to occasionally carry out maintenance actions. Each of these actions is both time consuming and incurs a monetary cost. While performing a maintenance action (which lasts several seconds), the spaceship 'freezes' and the player cannot shoot down any asteroids and thus is unable to gain any points (but at the same time it cannot lose points either). There are three levels of malfunctions: minor, moderate and severe. Each malfunction is associated with repair costs with respect to the score and time (i.e. the spaceship freezes during the repair time). The more severe the malfunction, the higher its repair costs. If a malfunction occurs, it starts off as a minor malfunction, the,n if not repaired, it may escalate to a moderate malfunction and eventually a severe malfunction. The moderate malfunction limits the movement and shooting rate of the spaceship, and a severe malfunction does not allow the ship to move or shoot until repaired. More details on how malfunctions are sampled and how maintenance actions may be used to avoid them appear in the next section. In this paper we study how an agent providing maintenance alerts may improve a player's performance in the spaceship game.

4. EVALUATION

In order to evaluate our agent and the maintenance alert method, we recruited a total of 66 subjects through Amazon's Mechanical Turk to play the spaceship game. These subjects played two games, one with alerts and the other without. The subjects performed significantly ($t(130) = 4.43$; $p < 0.0001$ using the student t-test) more maintenance actions when they received alerts than when they did not receive them, with an average increase of 58.7% in maintenance actions (5.46 vs. 3.44). However, subjects' score did not differ significantly when they received alerts and when they did not receive any alert. The alert system accounts for a non-statistical significant improvement of only 3.4% (2745.2 vs 2654.6). Figure 2 illustrates these results (error bars represent 95% confidence interval).

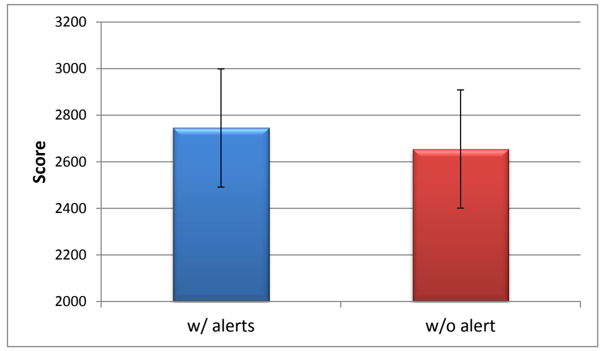

Figure 2: Average performance of subjects when receiving alerts and when not receiving alerts.

REFERENCES

[1] Piotr D Adamczyk and Brian P Bailey. If not now, when?: the effects of interruption at different moments within task execution. In *CHI*. ACM, 2004.

[2] A. Azaria, Y. Aumann, and S. Kraus. Automated strategies for determining rewards for humanwork. In *AAAI*, 2012.

[3] A. Azaria, Z. Rabinovich, S. Kraus, and C. V. Goldman. Strategic information disclosure to people with multiple alternatives. In *AAAI*, 2011.

[4] A. Azaria, Z. Rabinovich, S. Kraus, C. V. Goldman, and O. Tsimhoni. Giving advice to people in path selection problems. In *AAMAS*, 2012.

[5] Amos Azaria, Yonatan Aumann, and Sarit Kraus. Automated agents for reward determination for human work in crowdsourcing applications. *Autonomous Agents and Multi-Agent Systems*, 28(6):934–955, 2014.

[6] Amos Azaria, Avinatan Hassidim, Sarit Kraus, Adi Eshkol, Ofer Weintraub, and Irit Netanely. Movie recommender system for profit maximization. In *RecSys*, pages 121–128. ACM, 2013.

[7] Amos Azaria, Zinovi Rabinovich, Sarit Kraus, Claudia V Goldman, and Ya'akov Gal. Strategic advice provision in repeated human-agent interactions. In *AAAI*, 2012.

[8] Brian P Bailey and Shamsi T Iqbal. Understanding changes in mental workload during execution of goal-directed tasks and its application for interruption management. *ACM TOCHI*, 14(4):21, 2008.

[9] Ying Huang, Mickaël Gardoni, Amadou Coulibaly, et al. A decision support system designed for personalized maintenance recommendation based on proactive maintenance. In *ICED*, 2009.

[10] A. Rosenfend, I. Zukerman, A. Azaria, and S. Kraus. Combining psychological models with machine learning to better predict people's decisions. *SYNT*, 2012.

[11] Tammar Shrot, Avi Rosenfeld, Jennifer Golbeck, and Sarit Kraus. Crisp: an interruption management algorithm based on collaborative filtering. In *CHI*. ACM, 2014.

[12] Erwin C Vasbinder, Hettie M Janssens, Maureen PMH Rutten-van Mölken, Liset van Dijk, Brenda CM de Winter, Ruben CA de Groot, Arnold G Vulto, Patricia MLA van den Bemt, et al. e-monitoring of asthma therapy to improve compliance in children using a real-time medication monitoring system (rtmm): the e-matic study protocol. *BMC medical informatics and decision making*, 13(1):38, 2013.