Gaze-Contingent Enhancements for a Visual Search and Rescue Task

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1 Visual Inspection

An important task in many fields is the human visual inspection of an image. Those fields include quality control, medical diagnosis, surveillance and Wilderness Search and Rescue (WiSAR) [Goodrich et al. 2008]. The latter activity, triggered by an individual becoming lost, is the context within which this work proposes and evaluates a new approach to the task of human visual inspection.

The WiSAR task is often approached by conducting a systematic search of a region using a remotely piloted Unmanned Aerial Vehicle (UAV) [Simerson 2004]. A video camera underneath the UAV transmits a moving image of the terrain being overflown which is inspected by a human observer in order to locate a missing individual or relevant evidence.

2 Proposed Enhancement

Two enhancements to visual inspection were investigated: Magnification and Slowing. Both utilised the same extended gaze fixation detector to determine whether a subject was observing an object of interest on-screen. Should the subjects’ gaze remain fixated within a capture region of 35 pixel radius (equivalent to 5.3 m on the map or a visual angle of 1.7° on the screen) tracking the moving terrain for longer than 25 samples (416.7 ms), the enhancement was enabled. The Magnification or Slowing would cease when the gaze moved beyond this capture region for two consecutive samples.

The Magnification enhancement momentarily doubled the area under view, resulting in a magnifying lens with an effective radius of 128 screen pixels (map equivalent of 19.4 m), centred on the current eye position. The Slowing enhancement halved the apparent flight speed while enabled. Once disengaged, the flight speed is double the original for half the duration the enhancement was engaged, thus ensuring that the imagery presented to the user catches-up with the simulated live feed from the UAV.

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3 Experiment

To ascertain whether either of these two enhancements improved visual search performance, we conducted an experiment to compare both enhancements as well as a control at two common flight speeds for a WiSAR UAV: 97 and 144 km/h. We created a simulation of a real UAV flight, and its associated idealised capture of terrain imagery, by making use of a number of high resolution maps (1 pixel = 15.2 cm) of typical unpolluted terrain. Photographs of people viewed from above were then superimposed upon the maps.

4 Enhancement Effectiveness

The availability of the Magnification enhancement had little to no impact on the number of targets potentially identified compared to the control, whereas the Slowing enhancement resulted in a substantial detriment to visual search. The Wilcoxon test confirmed this finding with p < 0.01 (W = 272, N = 18). The enhancement events occurred more frequently for the Magnification mode than the Slowing mode. The average duration of tracking events above the threshold of 25 was 40 samples (666.7 ms) for the Magnification mode (M = 40.9, SD = 16.8, N = 177) and almost identical for the Slowing mode, despite fewer occurrences.

5 Participant Feedback

The subjective views of participants concerning distractiveness, usefulness and assistiveness were elicited by questionnaire. The latter two indicate a strong preference for Magnification over Slowing. The Wilcoxon test was used to confirm that both of these preferences are statistically significant. For usefulness question we obtained p < 0.01 (W = 418, N = 23) and a similar result for the assistiveness question. Views concerning distractiveness did not differ between enhancements. Some participants verbally suggested that they were altering their gaze-movements to selectively engage the gaze-contingent enhancements during the experiment. Such modification of eye-movement behaviour was used to engage the Magnification enhancement and suppress the Slowing enhancement. This behaviour was supported by the apparent halving of the number of tracking events per presentation for a given speed.

6 Conclusions

- Momentary magnification at ‘gaze-dwell’ sites led to higher target identification than with momentary slowing.
- It is worthwhile to investigate the magnification technique further in the context of Wilderness Search and Rescue.

References
