Weapon Detection in Image Fusion Using Systems Factorial Technology

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Introduction

Image fusion offers a potential method of making information provided easier to be perceived by combing images from multiple sensors into a single image.

Most quantitative approaches to assessing image fusion approaches rely on information metrics rather than human performance. Most human performance based assessments are qualitative, self-report metrics.

Previous research in our lab[1] found that side-by-side presentation resulted in equivalent or even enhanced performance compared to fused image presented.

We applied the capacity coefficient[2,3] to measure performance with fused and side-by-side imagery relative to a theoretically-motivated baseline model. This allows us to test and compare the efficiency of human perception of multi-spectral image across a range of fusion approaches.

One Sources

Visible Image IR- Image

Two Sources

Algorithmic- fused Image Cognitive- fused Image

$$C_{OR}(t) = \frac{H_{Fused(t)}}{H_{IR(t)} + H_{Visible(t)}} \quad \begin{array}{l} > 1 \textit{ super capacity} \\ = 1 \textit{ unlimited capacity} \\ < 1 \textit{ limited capacity} \end{array}$$

Methods

Subject

Ten observers participated in the study (male = 6, average age=23.8). All had normal or corrected-to-normal visual acuity, and normal color vision.

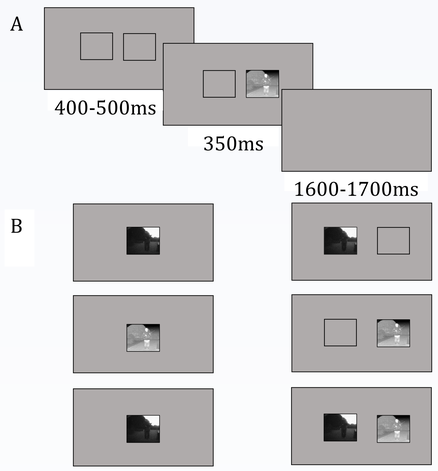
Task

Subjects were required to click mouse to indicate whether the female in the image is holding a gun or tool.

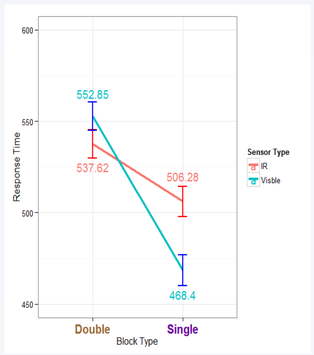
Stimuli

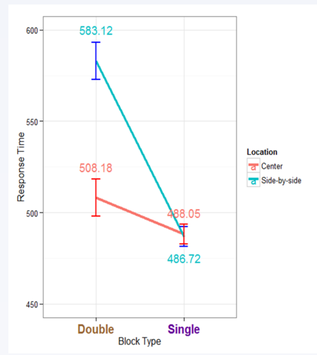
Example of images used in the experiment: visual images (A), IR images (B) and their corresponding fused images (C). There were two different tools and two different guns used for the task.

Procedure



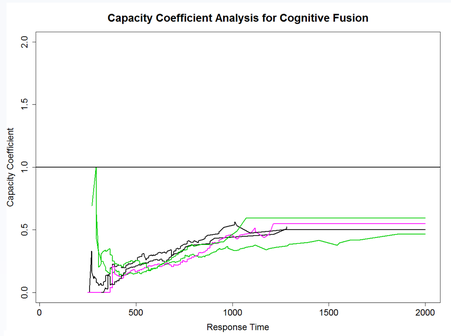
A: The procedure of a trial. B: center blocks (left) and side-by-side blocks (right) used in the experiment.

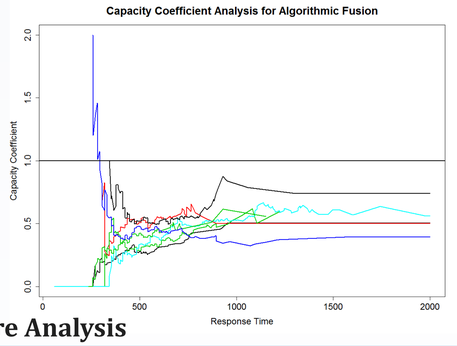




Capacity Coefficients

0.9 accuracy was set to cut for capacity coefficient.
7/10 subjects indicated limited capacity for cognitive fusion.
5/10 subjects indicated limited capacity for algorithmic fusion.
No statistically significant difference between limited capacity found.





Results

Repeated Measure Analysis

Response time

	Mean	df	F	Sig.	η^2
Number of resources	Single(M =515.83)	9	3.93	0.08	
	Two (M =530.83)				
Fusion Type	Alg (M =518.87)	9	1.21	0.30	
	Cog (M =542.19)				
Image Type	IR (M =521.71)	9	1.64	0.23	
	Vis (M =509.71)				
Number of Locations	Single(M =497.98)	9	19.60	<0.01	0.041
	Two (M =534.05)				
Block Type	Single(M =487.05)	9	40.68	<0.01	0.097
	Mix (M =545.20)				

Accuracy

	Mean	df	F	Sig.	η^2
Number of resources	Single(M =0.93)	9	1.48	0.26	
	Two (M =0.91)				
Fusion Type	Alg (M =0.88)	9	2.92	0.12	
	Cog (M =0.94)				
Image Type	IR (M =0.93)	9	0.50	0.50	
	Vis (M =0.93)				
Number of Locations	Single(M =0.94)	9	0.65	0.43	
	Two (M =0.92)				
Block Type	Single(M =0.91)	9	10.13	0.01	0.062
	Mix (M =0.94)				

Conclusion

Both algorithmic and cognitive fusion methods are capacity limited, the difference in them regarding their response times is not statistically significant.

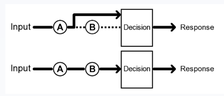
The process of switching attention between locations increases reaction times and reduces the advantage of visible images over IR images in this study.

The method of side-by-side presentation increases reaction times but results in equal performance compared to algorithmic fusion.

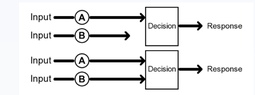
Future Research

Survivor Interaction Contrast

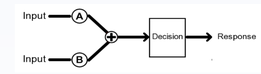
Serial



Parallel



Coactive



Explore architecture and stopping rule by salience manipulation to speed up and low down information processing.

Figure out the reason for limited capacity when redundant information provided in weapon detection task.

References

1 Fox, E.L. (2015). Cognitive analysis of multi-sensor information (Unpublished Master's thesis). Wright State University, Dayton, OH.

2 Townsend, J. T., & Nozawa, G. (1995). Spatio-temporal properties of elementary perception: An investigation of parallel, serial, and coactive theories. *Journal of Mathematical Psychology*, *39*, 321-359.

3 Houpt, J. W., Blaha, L. M., McIntire, J. P., Havig, P. R., & Townsend, J. T. (2014). Systems factorial technology with R. *Behavior research methods*, *46*, 307-330.

Acknowledgement

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