Developing new code for the Targeting Task Performance Metric

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Introduction

When soldiers want to quickly identify whether or not a target is a threat, they need to know what sensor they can utilize for assistance based on atmospheric conditions. The Targeting Task Performance Metric (TTPM) is “a model, which predicts the probability that he correctly identifies the target” (Vollmerhausen, Jacobs, Hixson, & Friedman, 2006). TTPM, shown in Figure 1, is computationally intensive to run so the United States Army Materiel Systems Analysis Activity (AMSAA) designed short-cut tables that “consist of a set of parameters which fit the TTPM to a function of atmospheric turbulence, apparent target contrast, target angular size (TAS), and scene contrast temperature or scene illumination” (Lai, 2018). This function is shown in Figure 2. The goal of this project was to develop new code for the Acquire-TAS of direct view optics (DVO). Research was then to be conducted on optimization schemes and the new code was to be utilized to develop two new optimization schemes for the Acquire-TAS of DVO. The optimization schemes were then to be used to replace the current optimization scheme and produce new short-cut tables for the Acquire-TAS of DVO.

Figure 1 (right): The TTPM function which integrates between spatial frequencies. TTPM takes the function $CTF_{SYS}(\xi)$ and the target modulation contrast (C_{TGT}) as inputs.

$$TTPM = \int_{\xi_1}^{\xi_2} \sqrt{\frac{|C_{TGT}|}{CTF_{SYS}(\xi)}}\, d\xi$$

$$TTPM = \begin{cases} A\left(C_{TGT} - X_{min}\right)^B & C_{TGT} > X_{min} \\ 0 & \text{otherwise} \end{cases}$$

Figure 2 (above): The power fit function to the TTPM function. This takes the target modulation contrast (C_{TGT}) and the parameters A, B, and X_{min} as inputs.

Materials and Methods

Acquire-TAS works by calculating the contrast threshold function (CTF) of the eye and of the image noise at every spatial frequency and light level in both the horizontal and vertical directions. Next, the optimization scheme selects turbulence indices that produce the minimum interpolation error. The CTF values along with other environmental variables such as target range, scene index of refraction factor, and the wavelength of the light are used to calculate the true TTPM at each light level and turbulence index. Finally, each short-cut parameter is calculated at

Materials and Methods (cont.)

each point in the interpolation grid. MATLAB was used for the coding of all provided functions and for the current optimization scheme. The TTPM integral and all of its component functions were coded. This included the CTF of the eye and of the optic being used, the Modulation Transfer Function for turbulence, and numerous unit conversion functions. After this, the power fit function to TTPM that was designed by the AMSAA and all of its component functions were coded. Next, the function for the impact on the task probability space was coded. Once all the required functions had been coded, extensive research was done on optimization schemes. While in the process of researching, the code that had been developed was found to be unusable and it was agreed that the scope of the project would be changed due to time constraint. The project was changed so that the new goal was to develop new code for the Acquire-TAS Table Creator (a macro-enabled Excel spreadsheet designed by AMSAA) for television sensors (TV) that replicates the original code. It was agreed that MATLAB would still be used for the new project goal. The methodology of TV and DVO is the same, but the math is different. Therefore, all of the mathematical functions previously coded were completely scrapped. Most of the code for the output of the six parameter tables was developed in addition to the new mathematical process. An example output parameter table is shown in Table 1.

Parameter		Turbulence Index									
		TI_{10}	TI_9	TI_8	TI_7	TI_6	TI_5	TI_4	TI_3	TI_2	TI_1
Light Level Index	LI_1										
	LI_2										
	LI_3										
	LI_4										
	LI_5										
	LI_6										
	LI_7										
	LI_8										
	LI_9										

Table 1 (above): This is an example of an optimized parameter table that the code would output. “Parameter” would be the name of the parameter, $TI_{1...10}$ are the ten turbulence indices picked by the optimization scheme. $LI_{1...10}$ are the ten standard light levels for TV. Inside the blue boxes would be the value of the parameter at every turbulence index and light level.

The output parameters include A_1, A_2, X_1, X_2, L, and B. The parameters shown in Figure 2 were estimated using linear regression and a relationship between X_{min} and the reciprocal of the target angular size.

Results

The code for the Acquire-TAS Table Creator for TV that replicates the original code was not finished successfully. The section of the project that was completed was coding the mathematical process. The table creation section was not finished. Due to a lack of time, no test of functionality was performed on the completed code.

Conclusion

Neither the code nor the optimization schemes for the Acquire-TAS of DVO were successfully developed. The original goal was not met since neither of its parts were completed. The final goal of the project was partially met. A majority of the new code for the Acquire-TAS Table Creator for TV was successfully developed, but was not finished or tested to guarantee that it replicates the original code. This was attributed to constraint on time. Even though the goals were not met, the project did have successful outcomes. All of the completed code can be utilized in the future by AMSAA or a student continuing this project. Once finished, the code could be tested, any errors could be fixed, and then it could be used for its intended purpose. In addition to this, the research done and the code developed can be used by AMSAA as reference when replicating the code for the Acquire-TAS Table Creator of different types of optics, such as DVO. Once all the tables have been optimized, Acquire-TAS could be utilized for its intended purpose by military personnel. Here, it could save time, money, and possibly lives from the increased chance of a user correctly identifying a target.

References

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