Automated Thermal Camouflage Generation Program Status

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ABSTRACT

The art of camouflage pattern generation has been based on heuristic techniques, combining both art and science. The difficulty with these techniques are that pattern must perform well in a variety of different background types and conditions. To develop a camouflage that performs well over a range of backgrounds and conditions one would like a computer technique capable of optimising a camouflage pattern over all these possible combinations. The first step in developing such a system is to be able to create a pattern from a specific background. Spatial and spectral algorithms are required to create a effective pattern. This paper outlines the progress of the SCI-114 technical working group to create a site specific, thermal camouflage pattern. Background selection, pattern generation, thermal paint characterisation, pattern field experiments and simulation work will be discussed.

1.0 BACKGROUND SELECTION PROCESS

Several background types were evaluated and two main areas selected to collect thermal imagery and ground truth data sets. The first area is a Canadian woodland background and the second was a high desert area in Spain. Background data as well as outdoor paint characterisation experiments were performed at each of the sites. Figure 1 shows a Canadian field trial.

Figure 1: Canadian Test Winter Trial

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The Canadian data was collected during winter conditions to determine performance of a snow foreground and woodland background condition. Various thermal paints with white pigments were measured in the scene. The second trial site was in Spain near Madrid. The paint system was a sand color thermal paint system with similar panel arrangements as the Canadian experiment. Figure 2 shows the Spanish trial site and configuration.

Figure 2: Spanish Test Range

Two kinds of paint samples were studied in the Spanish trial

- A group of four panels painted with the same uniform paint, with emissivity $\varepsilon = 0.96$.
- A group of four panels painted with a disruptive pattern, consisting in four paints of different low emissivities.

Figure 3 is a image of both groups of panels in the way they were disposed for the trials.

Figure 3: Uniform And Thermal Panels In Spain

In the following figures, 4 and 5, the pattern can be observed with more detail. Figure 4 is a closer image of the disruptive panel during the trials, that shows the appearance of the paint marks in the visible range. Figure 5 is a scheme that represents the distribution of the four different paints on the panel.

2.0 INSTRUMENTATION

The equipment used in the trials is shown below:

- AGEMA 570 camera (AME003-00) Data interval 8 – 12 µm.
- MERLIN NIR camera (AME052-00)
- Meteorological station GEÓNICA (AME018-00), with:
- Anemometer vane JOUNG (AME018-01)
- Temperature and humidity probe GEÓNICA (AME018-02)
- Piranometer THEMBRECHT (AME012-03)
- Register Datalogger HP 34970 A (AME038-00), with: 8 Thermocouples kind K, temperature range from –200ºC to 1100ºC

Figure 4 Thermal Panel

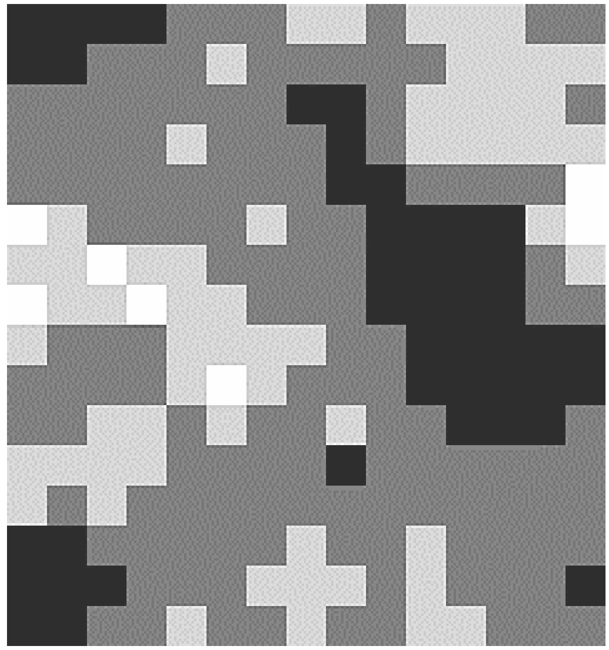

Figure 5 Paint Mask

3.0 MATERIAL CHARACTERISATION

The first step of the pattern generation process required a material characterisation step. Figure 6 shows a paint sample situated in Spanish trial background. Figure 7 shows an example of the thermal data that was collected which indicated the performance of the paint system in the background as well as the thermal variations of the background. Spatial patterns were then extracted to input into the pattern generation process.

Figure 6: Material Characterisation Trial

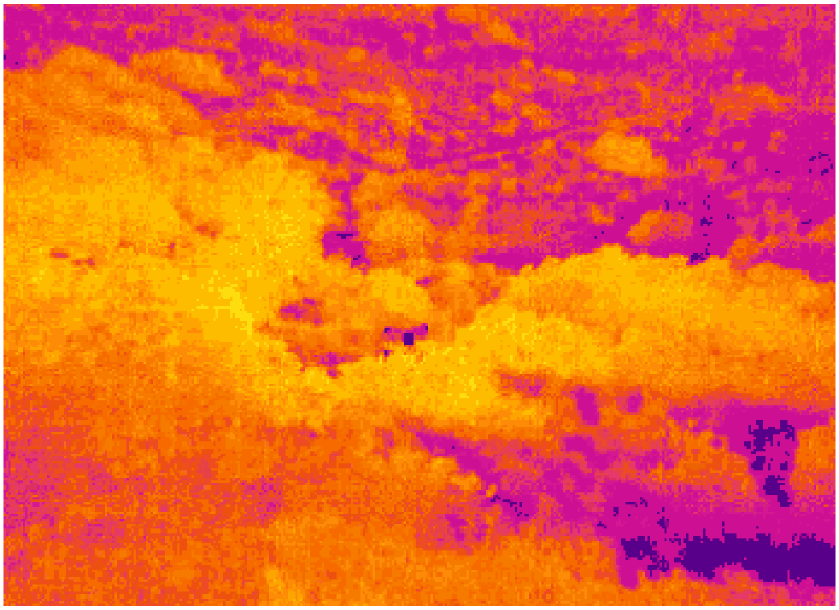

Figure 7: Material Characterisation Thermal Image

Once the patterns were generated a simulation was performed to see how the pattern may blend into the background area. Figure 8 show an example of this process. This is an example of optimum thermal match to check the spatial matching performance. One can see that a good match was achieved with this process. At a longer range, many of the details would blend into the background and not be easily resolvable. The pattern is generated with a specific sensor performance at a specific minimum range. The is a typical situation with camouflage that has resolvable elements.

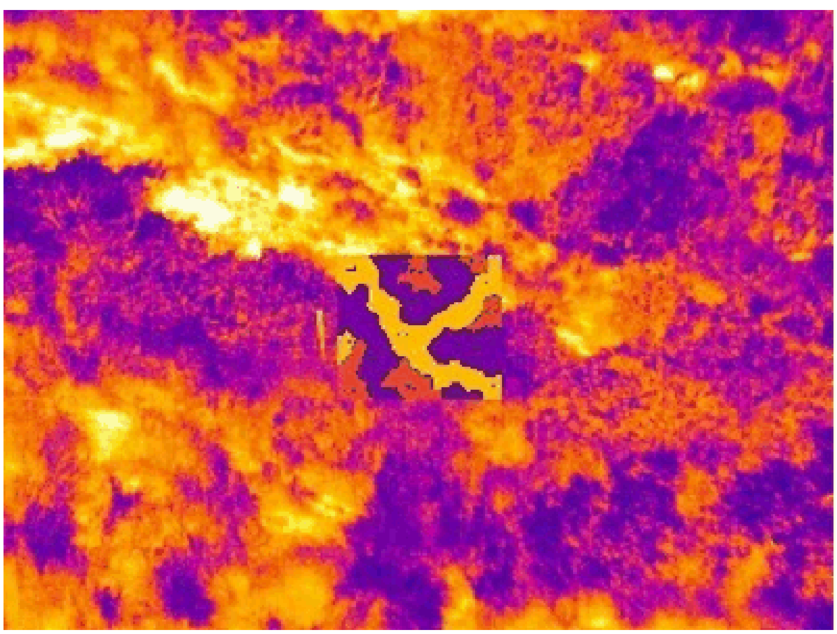

Figure 8: Simulation of Pattern in Background

The trials were run outdoors within the limits of the FNM test facility near Madrid Spain.. The distance between the samples and the instrumentation was 220 m.

The AGEMA 570 camera (the most important piece of equipment in this trial) was adjusted to take an image every 15 minutes. During preceding trials it was noted that significant variations of environment temperature produced defocusing of the camera lens. For this reason, turns were taken during the trials in order to watch over the correct focusing of the equipment.

The MERLIN NIR camera took an image every 15 minutes, except during the night (no signal available).

The meteorological station was programmed to monitor atmospheric conditions every 15 minutes. The weather was sunny, hot and without rain, with irregular cloudy intervals.

4.0 ANALYSIS OF FIELD EXPERIMENT DATA

A measure of effectiveness for this pattern system is a reduction in the probability of detection of the pattern system over a non-patterned system. This is the gold standard for performance of a camouflage system. As an indicator, metric analysis is performed to assess the temperature difference between the paint-pattern system and the uniform paint system. Figure 9 shows the process of creating various area of interest within the thermal image. The data analyst would draw a graphic box around the uniform pattern and one around the patterned panels. Another box is drawn to define the background area. The computer then calculates the temperature difference between each of the panels and the backgrounds to obtain a temperature difference. Generally speaking, the lower the temperature difference is the lower the probability of detection. This temperature difference analysis was completed on each of the pattern and uniform panels. Effective patterns provide a significant detection reduction over simple temperature analysis. These detection studies will be completed in the later portion of the program.

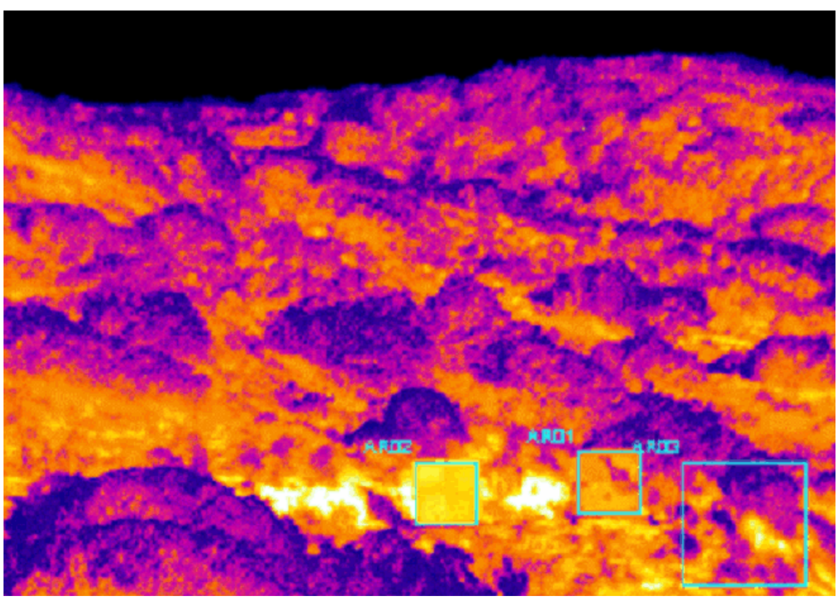

Figure 9: Data Reduction AIO Process

5.0 CAMEOSIM THERMAL SIMULATION

Simulation can provide an effective tool to extend the data sets that were collected in the field. Range, Aspect, Weather and environments can be changed in the computer to simulate different area, times and conditions. Simulation allows the analyst to add additional data that cannot be collected in the field due to the large cost of field trials. Figure 10 shows and example image of the Spanish trial site with the uniform and patterned panel.

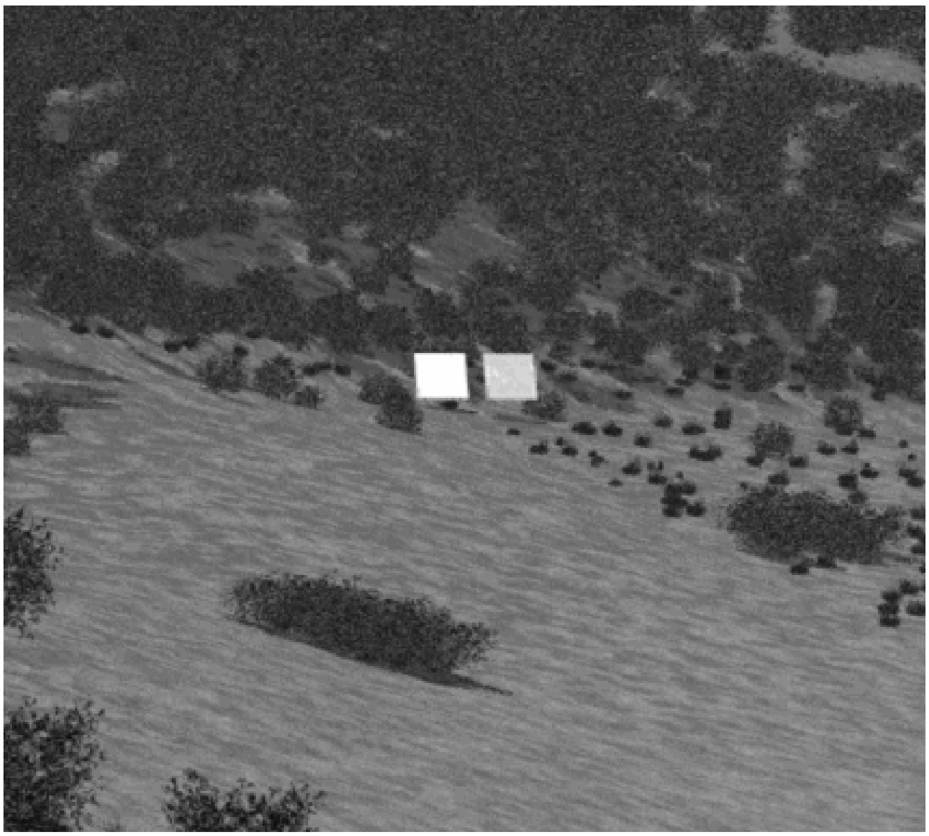

Figure 10: Thermal Synthetic Scene Simulation

Data sets of simulated imagery will be generated for a paired assessment observer experiment based on thermal predictive MUSES runs. Muses is a temperature prediction model used to generate the required data for the CameoSim rendering system. CameoSim then generates thermal imagery of the panels with various tilt angles and weather conditions. A design of experiment will provide the imagery required for the paired observer experiment. Various methods will be used to evaluate the synthetic imagery such as the FIRE metric tool, CAMEAV and conspicuity evaluation tool sets.

6.0 DIAGNOSTIC PANEL

Thermal camouflage patterns are subject to a wide variety of conditions that cannot be controlled during outdoor field trials. A simple method of experimenting with thermal camouflage patterns is to use a pattern diagnostic panel. Such a panel would ideally have small resolution cells which can be individually temperature controlled. The concept would be able to produce a specific average temperature and standard deviation of a predefined pattern relative to a background. This method allows the camouflage designer to assess the performance of a pattern under field trial conditions with the specific statistics required for the paired observer experiment.

A controllable diagnostic panel was designed and produced in this program to assess specific questions of the pattern generation performance. The panel consists of 25 individually controllable elements. A series of custom circuit boards were made to measure and control the panels and provide and interface to the computer controller. Figure 11 shows a cross section of the controllable element and figure 12 shows the computer control interface developed for this application.

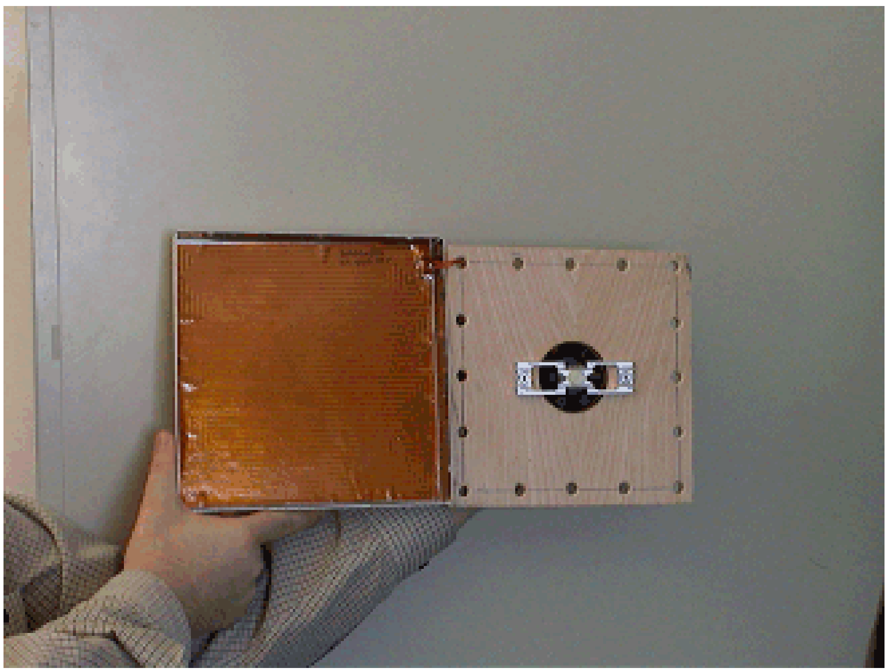

Figure 11: Cross Section of Diagnostic Panel

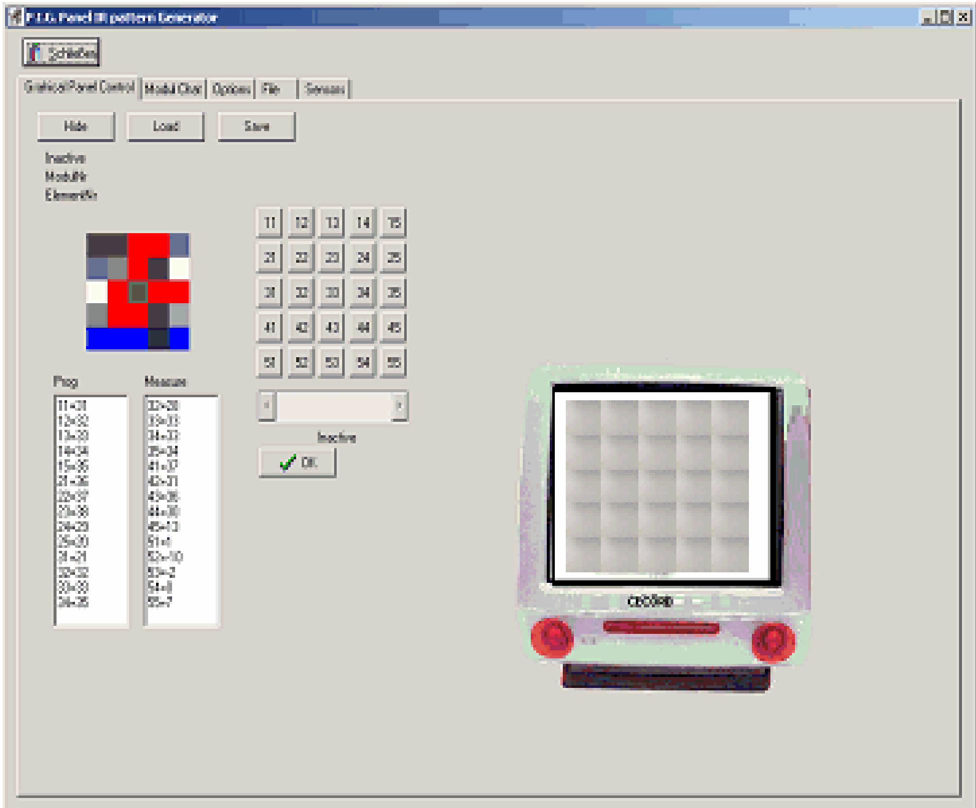

Figure 12: Diagnostic Panel Control

Using a cable car experimental range in Germany an experiment with the controllable panel will be conducted. This experiment will collect thermal imagery at various ranges. These images will be brought back to an observer laboratory to assess the detection performance differences between the various patterns and pattern average temperature. The resulting information will allow the camouflage designer to evaluate the relative probability of detection performance of the patterned system.

An image of the German cable car test range is shown in figure 13. The controllable panel can be put in various locations, in open field or along tree lines. The cable car starts its flight from about 3km range and has continuous motion to the target. Thermal cameras are mounted on the cable car for collection at specific range intervals.

Figure 13 Cable Car Test Location

7.0 CURRENT STATUS

The progress of the work in this group is as follows. Background data has been collected and analysed. Patterns have been generated based on a pallet of thermal paints. Panels were painted according to the generated patterns and tested at the Spanish trial site. Synthetic background data based have been generated with a higher resolution data set being completed.

Thermal predictions are being generated and compared to field measured data sets. Sequences of predictive data will be completed by late spring 2004. Paired observer experiments will be conducted to assess pattern performance over a wide range of conditions and panel orientation. Controllable panel experiments will be performed in late spring 2004 with analysis completed by the end of summer 2004. Final report with all data sets will be completed winter 2004.

8.0 ACKNOWLEDGEMENTS

This paper represents the work of the SCI-114 technical task group's members efforts over the last 3 years.

9.0 REFERENCES

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