

PTS MONTHLY CHECKLIST

Submitted by: *University of Michigan* Report Month: *AUGUST, 2000*
Submitted to: *U.S. Department of Energy/Albuquerque Office*
TTP No.: *ALO-7-C1-61 (UMichigan)*

EARNED VALUE ANALYSIS DATA. Check *one* box in Line A and *one* box in Line B.

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A. How is your project's schedule doing compared to your TTP baseline?

1. As planned

B. How is your project's total cost doing compared to your TTP baseline?

2. As planned.

PTS NARRATIVE INPUT CHECKLIST. Check that you have prepared the following narrative inputs:

1. **SIGNIFICANT ISSUES/PROBLEMS/CONCERNS:**
Note if there are any problems; otherwise, state "None." Report only problems considered "show-stoppers" or fatal flaws (i.e., a lack of funding will cause the project to be shut down).

NONE

2. **CORRECTIVE ACTION:**
If a significant issue/problem/concern in Section 1 above is described, this section is required; otherwise state "None needed."

NONE Needed

3. **SUMMARY ASSESSMENT:**
This should be a BRIEF paragraph summarizing the overall status of the project. This section is a synopsis of the entire report.

UM is preparing its current obstacle avoidance algorithm and platform for a major demonstration later this month. The initial prototype module of a novel vehicle formed from fused deposition modeling was received and the quality was disappointing. We are looking at alternative fabrication techniques. The radiation imaging work continues to involve renovation of the CSPD-2 camera, improvements to the Hybrid Imager, and work on the room temperature semiconductor detector arrays.

4. **COST VARIANCE:**
If you checked number 4 or 6 in the Earned Value Analysis section, you must provide an explanation here. Explain funding issues such as variances, carryover, commitments, incorrect FIS data. Avoid using only the words "Within budget." Some narrative is preferred.

Within Budget.

5. **SCHEDULE VARIANCE:**
If you checked number 3 or 5 in the Earned Value Analysis section, you must provide an explanation here. Note if the project is on schedule, ahead of schedule, or behind schedule. If behind, explain what is being done to bring the project back on schedule.

6. TECHNICAL STATUS:
 This is likely to be the longest section of the narrative and describes the technical accomplishments during the reporting period. Provide enough detail to inform, yet avoid extensive details that can confuse the reader.

6.1 OBSTACLE AVOIDANCE

6.1.1 Technology demonstration

UM has begun preparations for a major technology demonstration for UM's obstacle avoidance technology. The technology demonstration will require that UM's Pioneer robot travel through a maze of rooms that are connected by narrow doorways in a realistic, non-laboratory environment. The foremost challenge with this scenario is that obstacle avoidance is not synonymous with "passageway detection." This means that even though UM's technology is highly effective in avoiding unexpected obstacles, the absence of an obstacle (i.e., an open doorway) is not necessarily detected. As a result, UM's robot does not necessarily pass through open doorways, even if the open doorway would be the best choice for travel. UM is considering addressing this long-known problem by applying methods UM developed in the past for DOE's SWAMI robot, with the specific purpose of entering and navigating narrow passageways with extremely high reliability.

6.1.2 Random Sequence Sonar Firing Algorithm

One well-known limitation of UM's earlier developed EERUF method for detecting and rejecting ultrasonic sensor crosstalk is that EERUF only rejects false readings due to crosstalk but does not attempt to avoid the occurrence of crosstalk phenomenon itself. Thus, under certain environmental conditions, crosstalk can persist for several seconds and subsequent rejection of crosstalk-affected readings by EERUF will render the robot partially "blind" during this period.

In an attempt to overcome this problem we have turned our attention to a common technique used in adaptive systems to solve system-modeling problems. This technique is based on the use of random signals (white noise) as input to the system. The output of the system is then analyzed statistically to find relationships among inputs and outputs.

In order to apply this technique to the EERUF application we used random firing sequences and frequencies as the input and we analyzed the resulting output (number of good sonar measurements, number of rejected readings) under different conditions (open environments, cluttered rooms, etc.)

For our experiments we used a Pioneer platform with 10 sonars and we tested four different firing techniques

1. High frequency EERUF schedule firing each sonars at 10 Hz (EERUF-H)
2. Slow frequency EERUF schedule firing each sonars at 6.3Hz (EERUF-L)
3. Pseudo-random sequence, at 6.3Hz (P-RANDOM)
4. Random Firing sequence, at 6.3Hz (RANDOM)

The following table summarizes the results of the four techniques for 23 experiments.

Typical, average environmental conditions (few reflective walls nearby)				
	EERUF-H	EERUF-L	P-RANDOM	RANDOM
Valid readings:	68.89	78.70	91.71	91.40
Errors:	8.03	7.21	2.70	3.00
Crosstalk:	23.06	14.08	5.56	5.60
Very favorable environmental conditions (wide open space)				
Valid readings:	89.74	92.02	99.60	98.96
Errors:	0.24	0.00	0.00	0.00
Crosstalk:	2.57	2.23	0.40	1.04

Worst environmental conditions (highly reflective walls nearby)				
Valid readings:	26.73	61.96	78.64	77.44

Based on these results we conclude that the P-RANDOM method is substantially better than the earlier EERUF method and we will now conduct field experiments to confirm that conclusion.

6.1.3 Binaural sonar techniques

UM is has begun a new, multi-year project aimed at exploiting previously unused information inherently available in echoes from objects resulting from ultrasonic “illumination.” Most existing sonar-based obstacle avoidance systems use the Polaroid sensors, which are designed to measure the time between sending the signal and receiving the first echo. This approach requires only minimal hardware and is favored because of the simplicity with which it can be implemented. However, the approach fails to exploit subsequent echoes that might be caused by other objects. More importantly, the conventional approach makes no effort to correlate these binary echo signals to their sonar sources. Therefore, echoes to signals emitted by one sonar can be received by another, thereby causing the crosstalk problem that was already mentioned in the previous section.

UM’s newly proposed binaural sonar approach aims at high-speed sampling of each sonar’s output, and developing methods for analyzing that data so as to make optimal use of all of the embedded information. We will continue reporting on this research in the following months.

6.2 Position Estimation

UM is pausing its ongoing development of position estimation technologies in order to summarize and document our significant progress over the last two years. It is expected that the documentation effort will continue through the next few months and will likely result in several publications.

6.3 Novel mobility concepts

OmniPede

UM has produced another set of parts using the Fused Deposition Manufacturing (FDM) process. This time the results were disappointing in that there was significant warping in some of the parts. We believe that this is the result of inadequacies with UM’s in-house FDM facility, which is mostly used for instructional purposes. We will try manufacturing these parts again, this time with the help of a commercial manufacturer. We are still convinced that the FDM process is the most suitable way of manufacturing the highly complex parts required for the OmniPede platform. However, we are now also investigating two similar manufacturing processes: stereolithography and laser sintering. These new processes will have all of the advantages of the FDM process, but they each promise to solve different problems we encountered with FDM. Stereolithography has excellent feature definition and accuracy, but the material used can be brittle. The process of laser sintering can be used to make parts of ABS plastic but we need to get more experience with this process before we can decide on its suitability.

6.4 Vision for Navigation and Mapping

Additional work has been done in preparation for the large scale map-building experiment. Several improvements have been made to the structured light system. We have switched to a 3-sided target that uses a grey and white checkerboard pattern for the calibration target. In conjunction with this, we have switched to a Harris corner detector for image plane feature localization. Calibration using this combination was found to be superior to other, previous calibration targets that use either separated grey squares on a white background, or intersecting black lines on a white background.

In addition, we have prepared a draft report discussing the methods for using physical models to extract diffuse reflectance from laser range images. A final report on feature-based registration should be completed in September.

6.5 Radiation Detection and Imaging

As described in last month's report, we are restoring an earlier camera to functional condition. It is interesting to see how, over a period of one year, the electronics had degenerated. We anticipate the camera to be functional again by the end of next month and have begun testing it using point sources.

We're anticipating the arrival of new electronics for the room temperature detectors under development. We are also anticipating a return of one detector currently undergoing repair at NASA Goddard. In the meantime, we have been looking for ways to overcome limitations introduced by Doppler corrections caused by the finite momentum of detector electrons.

7. MAJOR ACCOMPLISHMENTS:

Note MAJOR accomplishments during the reporting period; "None" is a valid, *occasional* entry.

Our paper (Owed, L. and Borenstein, J., 2000, "Experimental Results With the KVH C-100 Fluxgate Compass in Mobile Robots") was presented at the IASTED International Conference on Robotics and Applications 2000, Aug. 14-16, Honolulu, Hawaii, Proceedings pp. 156 -162.

MILESTONES. *Check that you have updated the status of your milestones.*

1. MILESTONE STATUS UPDATES:

Make sure you have provided a brief, one- or two-sentence comment on each active milestone and completion/new forecast date as appropriate.

No milestones were due this month.