PTS MONTHLY CHECKLIST

Submitted by: *University of Michigan* Report Month: *SEPTEMBER, 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.*

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

[X] 1. As planned [ ] [ ]

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

[X] 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.

During this reporting period, Mich. dedicated its efforts to performing a major technology demonstration near Washington D.C. Our obstacle avoidance technology was tested in an unstructured, chalenging indoor environment, and performed flawlessly on board a Pioneer robot. Two archival publications were prepared and submitted based upon the sensor work accomplished this past summer. Joint radiation imaging work between Michigan and Florida was planned. Michigan also attended and presented work at the Spectrum 2000 conference in Chattanooga, Tennessee.

[ ] **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 successfully completed a major technology demonstration for its obstacle avoidance technology. The technology demonstration required that UM's Pioneer AT 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 was that the doorways were very narrow, leaving less than 2 inches of space on either side of the robot.

In order to implement this task UM made several internal design changes in its software, which, together, proved successful in providing the desired functionality. UM is now investigating the utility of narrow passageway navigation for specific DOE tasks. If it is found that this capability is desirable, UM will begin an effort of 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 Binaural sonar techniques

UM has begun a new effort toward the development of novel techniques, in which sonars include a distinguishable "signature" within the burst of ultrasound they emit when "firing." Without this signature sonar-based systems must assure that one sonar does not receive an echo to a signal emitted by another sonar (a phenomenon called "crosstalk"). UM's earlier developed EERUF method was capable of detecting and rejecting crosstalk, and thereby greatly improved the possible firing rates and reliability of the system.

In the signature-based system now being developed at UM, crosstalk is no longer an undesirable phenomenon. Rather, since the source of echoes can be identified, crosstalk becomes desirable because echoes from other sonars on-board can provide additional geometric information about the exact obstacle location. In preliminary experiments we have already shown that under ideal lab conditions the relative position of individual objects can be pinpointed to within just a few centimeters, both radially and angularly (in conventional sonar systems the radial distance was always very accurate, but the angular relative position was very inaccurate, due to the width of the conical propagation pattern of ultrasound).

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 journal publications.

6.3 Novel mobility concepts

OmniPede
The OmniPede project is temporarily halted because the M.Sc. student has graduated. UM is currently training a new student to continue this project.

6.4 Vision for Navigation and Mapping

For September, most of our effort was devoted to documentation of research conducted in the spring and summer. We have completed the final report on feature-based ICP registration, and submitted it as "ICP Registration using Invariant Features" to IEEE Transactions on Pattern Analysis and Machine Intelligence. Further, we have prepared a preliminary report on our multiview registration method, which has been submitted to IEEE International Conference on Robotics and Automation, 2001.

6.5 Radiation Detection and Imaging

University of Michigan and University of Florida researchers have met and planned joint radiation imaging activities. A Florida professor will be traveling to Michigan to perform an imaging experiment utilizing the facilities at the Ford nuclear reactor during October-November 2000. Michigan will provide a radiation imaging camera and radioactive sources to test the Florida imaging algorithms.

Work continues on isolating those factors which can enhance the performance of the new hybrid gamma camera. Utilizing improved system modelling, we have seen a significant improvement in the quality of reconstructed images from this device.

7. MAJOR ACCOMPLISHMENTS:

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

Technology demonstration

On September 28, 2000 UM demonstrated its obstacle avoidance and position estimation technologies at a large Technology Demonstration event near Washington D.C. An audience of about 150 invited guests from government, military, and industry attended this half-day event. There were some 30 technology demonstrations presented by industry and universities. Among the 30 or so mobile robots demonstrated there were numerous Urbie and other tracked platforms, Pioneer AT four wheel-drive/skid-steer robots, two model-sized semi-autonomous helicopters, and numerous other platforms.

Most demonstrations were outdoors, while some, including that of UM, were indoors. Many of the demonstrations failed at some time, predominantly due to power issues, R/F communication problems, or, in case of the Urbie tracked platforms, due to detracking (i.e., a track detaching). UM's demo (described in the Obstacle Avoidance section above), however, performed flawlessly. In addition to the impressive performance of indoor obstacle avoidance through narrow doorways, UM's mobile robot produced an accurate map with its ultrasonic sensors while moving through the unknown indoor environment. For the purpose of the demonstration UM recorded the map building process off the onboard computer's screen and streamed this video recording to the visitors' control room in parallel with the actual mobile robot motion. As a further test and dramatic illustration of one inherent advantage of ultrasonic sensor-based obstacle avoidance, UM performed its demo in the presence of thick theatrical smoke that filled the demo rooms and hallways to the extent that an observer walking closely behind the robot could not see the robot. In an additional test, conducted after the formal technology demo, UM filled the rooms and hallways of the demo building with smoke from a military smoke grenade. The purpose of this test was to evaluate the effect that relative coarse particles, present in some smoke, would have on the sonar-based obstacle avoidance. Our test showed that the sonar system again performed flawlessly, even in the presence of particle-laden smoke. The smoke resilience tests are of interest in applications such as victim recovery after earth quakes or other catastrophic events where smoke resilience may be beneficial.

Robot book

DOE-funded work at UM, namely, the OmniMate robot platform, was featured in the new book "Robo Sapiens: Evolution of a New Species" by Peter Menzel and Faith D'Aluisio, MIT Press; ISBN: 0262133822, Amazon.com Sales Rank: 596.

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

1. MILESTONE STATUS UPDATES:
Make one or two-sentence comment on each active milestone and completion/new forecast date as appropriate.

No milestones due this month.