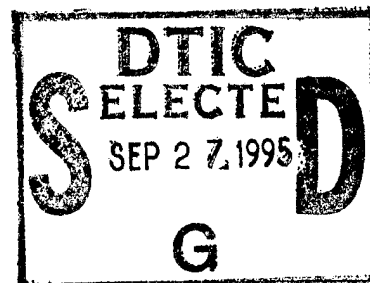Quarterly Progress Report, Feb 1994 — Apr 1994
ONR Contract Number N00014-93-1-1235
Drew McDermott, PI
Yale University Department of Computer Science

We continued our work on perception-based planning and execution:

- In the area of visual tracking, Greg Hager and his students have demonstrated the ability to perform distraction- and occlusion-resistant tracking of closed contours. The novel features of our approach are: a foveal/peripheral approach to image processing that is used to detect approaching contours, and a discrete-event system which is used to predict the possible appearances of a feature if an approaching contour were to cross it. Tests of the system have shown it to be extremely robust to distractions (objects moving behind the tracked target) and robust to occlusion provided sufficient unoccluded area remains to maintain contact with the contour. We are currently working to improve the performance of the system, and to incorporate these ideas into other systems using feature tracking.

- In the area of visual servoing, we have for the first time demonstrated full six degree-of-freedom visual servoing using calibration insensitive feedback algorithms. Based on this demonstration, we are designing a more ambitious visual servoing system that will support fast and easy reconfiguration for a variety of manipulation tasks.

- Sean Engelson completed the experiments for his dissertation on robot mapping. The last experiment involved the "trash collection" domain, a simulated world in which the robot had to find randomly strewn pieces of trash and find trash cans to put them into. The experiment compare the behavior of Engelson's map-based planner with a purely reactive system that search randomly for a trash can each time. The map-based system recorded the positions of trash cans when first sighted, and was able to navigate back to them later. At first, the two systems performed about equally well, because they both tended to find trash near a can. As trash was collected, however, the map-based system did much better. because the time it took to find a can did not rise precipitously. These results will be reported at greater length in a journal publication.

- Work by Hemant Tagare and Drew McDermott on visual object recognition continued. In earlier periods, we worked on finding object-contour fragments in the image, and matching them to the model of the object sought. In the period being reported, our focus was on combining fragment matches into an overall interpretation. The problem is to avoid potential combinatorics. We have begun tests with a "greedy" algorithm that seems to work well. The algorithm keeps track of a set of interpretations, each consisting of a set of contour-fragment matches. On each iteration, each interpretation is extended by adding a match that is consistent with it; i.e., for which there is a pose and scale of the object model which would give rise to the edges seen in the augmented interpretation. Once a fragment match is added to a feasible interpretation. it is discarded, so that it does not give rise to any further interpretations. thus minimizing the combinatorial explosion.

Activities:

Gregory Hager, "Decision Algorithms for Model-Based Decision Problems in Vision." "Workshop on Theoretical Foundations of Computer Vision." Dagstuhl. Germany
Drew McDermott, presentation on "Probabilistic Projection for Planning." Georgia Tech. Feb. 3
Drew McDermott, panel discussion on "Mixed-Initiative Planning." ARPA/Rome Lab Planning Initiative, quarterly meeting, Feb. 22-25.
Drew McDermott, presentation on "Probabilistic Projection for Planning." March 30

DTIC QUALITY INSPECTED 5

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Sep 27, 1994

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800 north Quincy Street
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Code A. Watson

1. Reference: DoD Directive 5230.24, Distribution Statements on Technical Documents, 18 Mar 87.

2. The Defense Technical Information Center received the enclosed report (referenced below) which is not marked in accordance with the above reference.

Contract No. N00014-93-I-1235
Quarterly Progress Rpt Feb 1994 – Apr 1994

3. We request the appropriate distribution statement be assigned and the report returned to DTIC within 5 working days.

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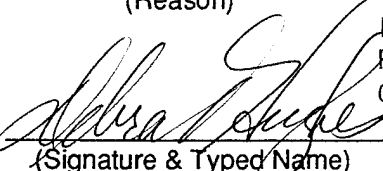Below) or HIGHER DOD AUTHORITY.

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18 SEP 1995
_____
(Date Statement Assigned)

LEDGER DESCRIPTION	AMOUNT BUDGETED	COMMITTED (NOT PAID)	PAID TO DATE	TOTAL EXPENSES	REMAINING BALANCE
NON-LADDER ACAD $	44,765	9,217.32	7,433.35	16,650.67	28,114.33
RES APPTS FACULTY SUMMER COMP	55,084	38,000.00	.00	38,000.00	-17,084.00
MANAGERIAL & PROFESSIONAL	9,905	12,090.08	8,428.45	20,518.58	-10,613.53
STUDENT ASST.	21,310	9,260.67	21,793.03	31,053.70	-9,743.70
EMP. BENEFITS	36,208	19,613.32	5,163.21	24,776.53	11,431.47
D/P SUPPLIES	0	-220.00	220.00	.00	.00
MINOR EQUIPMENT & FURNISHINGS	0		252.95	252.95	-252.95
D/P SVS.	3,076	15,614.00	5,689.00	21,303.00	-18,227.00
D/P SOFTWARE	0		139.00	139.00	-139.00
FREIGHT & TRANSPORTATION	0	95.25	98.88	194.13	-194.13
PHOTOCOPYING	795.00	501.68	630.50	1,132.18	-337.18

Publications:

   Task-Directed Computation of Qualitative Decisions from Sensor Data. To appear in the IEEE Transactions on Robotics and Automation.

   Drew McDermott 1994 An Algorithm for Probabilistic, Totally-Ordered Temporal Projection. Yale Computer Science Report 1014. Submitted to *Artificial Intelligence*

Personnel Support:

- *Graduate Students (full time):* Michael Beetz. Wenhong Zhu. Aage Bendiksen, Kentaro Toyama

- *Post-doc (half-time):* Hemant Tagare

- *Secretary (half-time):* Paula Murano

Expenditures:

   The accompanying table shows the figures for expenditures to date. including amounts committed but not actually spent.

LEDGER DESCRIPTION	AMOUNT BUDGETED	COMMITTED (NOT PAID)	PAID TO DATE	TOTAL EXPENSES	REMAINING BALANCE
MISC SERVICES	0		36.00	36.00	-36.00
TRAVEL (DOMESTIC)	0	1.283.00	2.179.01	3,462.01	-3,462.01
TRAVEL (FOREIGN)	0		2,913.98	2.913.98	-2.91
CONFERENCE & SEMINAR FEES		150.00		150.00	-150.00
OFFICE SUPPLIES	489	138.09	3.93	142.02	346.98
PERIODICALS	0	.00	219.35	219.35	-219.35
POSTAGE	0	31.51	282.77	314.28	-314.28
TUITION REMISSION	2.839		16,880.00	16,880.00	-14,041.00
HEALTH INS.	0		896.00	896.00	-896.00
TELEPHONE	495	175.00	109.66	284.66	210.34
DATA PROC. EQUIPMENT	15,007	.00	4.302.20	4.302.20	10,704.80
INDIRECT (OVERHEAD 64.0%)	110.162	67.807.93	34.287.78	102.095.71	8,066.29
TOTAL:	300.135	173.757.85	109.045.07	282.802.92	17,332.08
OVERHEAD ANTICIPATED:					6,763.74
SPENDING BALANCE AVAILABLE AS OF JULY 01. 1994:					10,568.34

Overall Status and Plans:

We are quite happy with the rapid progress we are making on guidance of behavior using feature tracking, and we expect that to continue.