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<small>Please refer to the instructions for the collection of information to estimate an average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of the collection of information, including suggestions for reducing the burden, to Washington Headquarters Service, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188), Washington, DC 20503.</small>			
1. AGENCY USE ONLY (Leave blank)	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED Quarterly (9/1/93-12/1/93)	
4. TITLE AND SUBTITLE Representation & Recognition with Algebraic Invariants & Geometric Constraint Models		5. FUNDING NUMBERS DARPA Order No.: 8228	
6. AUTHOR(S) Dr. Joseph L. Mundy		Contract No.: MDA972-91-C-0053	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) GE - Corporate Research & Development P.O. Box 8 (K1, 5C39) Schenectady, NY 12301		8. PERFORMING ORGANIZATION REPORT NUMBER	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) DARPA/SISTO		10. SPONSORING/MONITORING AGENCY REPORT NUMBER	
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13. ABSTRACT (Maximum 200 words) <p>The theory of invariants of repeated structures has been validated experimentally. This class of object description appears very promising and extends the usefulness of invariants to a broad class of man-made objects.</p>			
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Sponsored by  
Advanced Research Projects Agency  
Software & Intelligent System Technology Office  
Representation and Recognition  
With Algebraic Invariants and  
Geometric Constraint Models  
ARPA Order NO. 8228  
Program Code No. N/A  
Contract No. MDA972-91-C-0053  
Sept. 1, 1993 - Dec. 1, 1993

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**Building KW, Room C248  
July 29, 1994**

**DARPA/SISTO  
Virginia Square Plaza  
3701 N. Fairfax Drive  
Arlington, VA 22203-1714**

**Attn.: Dr. Oscar Firschein**

**Subject: Quarterly Reports**

**Reference: Contract #MDA972-91-C-0053 titled "Representation and Recognition with Algebraic Invariants and Geometric Constraint Models".**

**Please find enclosed one copy of the above-referenced report for the quarter ending December 1, 1993. It is provided to you per Section F-67 of the referenced contract. This report is approved for Public Release - Distribution Unlimited.**

**Please call if you have further questions.**

**Regards,**



**Elizabeth J. Malloy  
Contract Administrator  
Tel: (518) 387-7850, (FAX -7962)**

**Enclosures**

- cc:**
- 1. Defense Technical Information Center  
Cameron Station, Attn.: DTIC-FDAC  
Alexandria, VA. 22304-6145 (two copies)**
  - 2. DARPA/SISTO  
Attn.: Edward R. Brown  
3701 North Fairfax Drive, 7th Floor  
Arlington, VA 22203-1714**

## **Progress**

Sept. 1, 1993 - Dec. 1, 1993

Progress during this period is as follows:

- Initial experiments to test invariants for 3D repeated structures indicate that reliable affine structure can be recovered for translational symmetries.
- An algorithm for matching triples of parallel lines based on length ratio invariants has been evaluated and gives reliable results on Fort Hood test imagery.
- An occupancy measure, based on the statistics of edgel chains and chain junctions has been evaluated and gives reasonable qualitative results on various parking areas at the Fort Hood site.

## **Activities For Next Reporting Period**

The work planned for the next reporting period is as follows:

- Participate with AAI in the updating of the IUE specification.
- Upgrade the invariants recognition system in Target Jr with a new class hierarchy design.
- Evolve a new architecture for 3D object recognition based on model classes which support the computation of invariants from single 2D image views.

## **Equipment Purchased**

None

## **Changes in Key Personnel**

None

## **Summary of Information**

The theory of invariants of repeated structures has been validated experimentally. This class of object description appears very promising and extends the usefulness of invariants to a broad class of man-made objects.

## **Areas of Concern**

None

## **Related Accomplishments**

A second international workshop on invariants was held in Porto Delgada, Azores, co-sponsored by ARPA and ESPRIT, on October 9-14. Over 30 participants exchanged new results on the theory and implementation of invariant-related research.

**COST AND MANHOUR TRACKING REPORT**

CONTRACT NO: MDA972-91-C-0053  
 CONTRACTOR: GENERAL ELECTRIC CO  
 CORPORATE RESEARCH & DEVELOPMENT

REPORT DATE: November 1993- FW348  
 5340-8-9064

**Representation & Recognition with Algebraic Invariants**

	PRIOR YEARS		LAST MONTH YTD	CURRENT MONTH	CURRENT MONTH YTD	TOTAL TO DATE
	1991	1992				
MATERIALS	0.4	70.6	82.84	4.2	87.08	158.110
DIRECT LABOR	60.3	154.8	74.1	0.0	74.1	289.184
PROJECT COST	145.8	434.4	251	4.3	255.25	835.480
EAC	9.2	21.3	13.8	0.2	14.0	44.511
B&P	0	0.0	23.8	0.4	24.2	24.249
COST OF MONEY						
D/L	7.1	13.7	6.3	0.0	6.3	27.076
P/C	0.1	0.1	0.0	0.0	0.0	0.200
FEE	4.9	14.1	8.9	0.1	9.0	28.059
TOTAL CONTRAC	167.0	483.7	303.8	5.0	308.9	959.575

**PROJECT COST**

TASKS	MANHOURS		PROJECT COST	
	YTD/91/92	YTD/93	PRIOR YEARS TTD - P/C	1993 TTD - P/C
ALL	2820	1151.2	580.2	650.7
TOTAL		3971.2	580.2	650.7
			255.3	308.9
			255.3	308.9
				959.6
				959.6

P.S. The correct manhours for October is: 1151.2 . 0 hours for November.

O. Erwin 12/8/93

Algebraic 10/83

**COST AND MANHOURL TRACKING REPORT**

CONTRACT NO: MDA972-91-C-0053  
 CONTRACTOR: GENERAL ELECTRIC CO  
 CORPORATE RESEARCH & DEVELOPMENT

REPORT DATE: October 1993- FW344  
 5340-8-9064

**Representation & Recognition with Algebraic Invariants**

	PRIOR YEARS		LAST MONTH YTD	CURRENT MONTH	CURRENT MONTH/YTD	TOTAL TO DATE
	1991	1992				
MATERIALS	0.4	70.6	81.69	1.2	82.84	153.870
DIRECT LABOR	60.3	154.8	72.9	1.2	74.1	289.179
PROJECT COST	145.8	434.4	247.22	3.8	251	831.230
EAC	9.2	21.3	13.6	0.2	13.8	44.277
B&P	0	0.0	23.5	0.4	23.8	23.845
COST OF MONEY						
D/L	7.1	13.7	6.2	0.1	6.3	27.076
P/C	0.1	0.1	0.0	0.0	0.0	0.199
FEE	4.9	14.1	8.7	0.1	8.9	27.911
TOTAL CONTRAC	167.0	483.7	299.2	4.6	303.8	954.539

**PROJECT COST**

TASKS	MANHOURS		PROJECT COST	
	YTD/91/92	YTD/93	PRIOR YEARS TTD - P/C	1993 TTD - P/C
ALL	2820	1127.2	580.2	251.0
TOTAL		3947.2	580.2	251.0
				TOTAL
				954.5
				954.5

O. Erwin 11/4/93

Algebraic 9/93

**COST AND MANHOUR TRACKING REPORT**

REPORT DATE: September 1993- FW339  
5340-8-9064

CONTRACT NO: MDA972-91-C-0053  
CONTRACTOR: GENERAL ELECTRIC CO  
CORPORATE RESEARCH & DEVELOPMENT

**Representation & Recognition with Algebraic Invariants**

	PRIOR YEARS		LAST MONTH YTD	CURRENT MONTH	CURRENT MONTH/YTD	TOTAL TO DATE
	1991	1992				
MATERIALS	0.4	70.6	81.62	0.1	81.69	152.720
DIRECT LABOR	60.3	154.8	67.4	5.5	72.9	288.021
PROJECT COST	145.8	434.4	234.6	12.6	247.22	827.450
EAC	9.2	21.3	12.9	0.7	13.6	44.070
B&P	0	0.0	22.3	1.2	23.5	23.486
COST OF MONEY						
D/L	7.1	13.7	5.7	0.5	6.2	26.978
P/C	0.1	0.1	0.0	0.0	0.0	0.198
FEE	4.9	14.1	8.3	0.5	8.8	27.777
TOTAL CONTRAC	167.0	483.7	283.8	15.4	299.3	949.959

**PROJECT COST**

TASKS	MANHOURS		PROJECT COST	
	YTD/91/92	YTD/93	PRIOR YEARS TTD - P/C	1993 TTD - P/C
ALL	2820	1127.2	580.2	247.2
TOTAL		3947.2	580.2	247.2
			299.3	950.0
			299.3	950.0

O. Erwin 10/13/93

**GE Corporate Research & Development**  
**Representation & Recognition with Algebraic**  
**Invariants & Geometric Constraint Models**  
**DARPA Order No. 8228**  
**Contract No. MDA972-91-C-0053**

**R&D Status Report**  
**Program Financial Status**  
**Quarter Ending December 1, 1993**

	<u>Planned</u> Expend.	<u>CUMULATIVE TO DATE</u> Actual Expend.	<u>%</u> Compl.	<u>AT COMPLETION</u> BAC	<u>LRE</u>	<u>Remarks</u>
Subtotal	972,386	835,487	85.9	1,447,606	1,447,606	
Management Reserve						
Unallocated Resources						
<b>TOTAL</b>	<b>972,386</b>	<b>835,487</b>	<b>85.9</b>	<b>1,447,606</b>	<b>1,447,606</b>	