16:05:01 OCA PAD AMENDMENT - PROJECT HEADER INFORMATION 06/05/96

Active

Project #: E-25-T72 Cost share #: Rev #: 2
Center # : 10/24-6-R8615-0A0 Center shr #: OCA file #:
Work type : RES
Contract#: IRI-9526322 Mod #: NO COST EXT Document : GRANT
Prime #: Contract entity: GTRC

Subprojects ? : N CFDA: 47.070
Main project #: PE #: N/A

Project unit: MECH ENGR Unit code: 02.010.126
Project director(s):
BOOK W J MECH ENGR (404)894-3247

Sponsor/division names: NATL SCIENCE FOUNDATION / GENERAL
Sponsor/division codes: 107 / 000

Award period: 950715 to 961231 (performance) 970331 (reports)

Sponsor amount	New this change	Total to date
Contract value	0.00	49,950.00
Funded	0.00	49,950.00
Cost sharing amount		0.00

Does subcontracting plan apply ?: N

Title: EXPLORATORY RESEARCH ON CONTROLLED PASSIVE HAPTIC DISPLAYS

PROJECT ADMINISTRATION DATA

OCA contact: Michelle A. Starmack 894-4820

Sponsor technical contact

HOWARD MORAFF
(703)306-1928

NATIONAL SCIENCE FOUNDATION
4201 WILSON BLVD.
ARLINGTON, VA 22230

Sponsor issuing office

LEE A DEHERRERA
(703)306-1212

NATIONAL SCIENCE FOUNDATION
4201 WILSON BLVD.
ARLINGTON, VA 22230

Security class (U,C,S,TS) : U ONR resident rep. is ACO (Y/N): N
Defense priority rating : N/A NSF supplemental sheet
Equipment title vests with: Sponsor GIT X

Administrative comments -
ISSUED TO GRANT NO COST EXTENSION TO 12/31/96 IAW OPAS FORM AND LETTER TO NSF DATED 6/5/96. FINAL REPORT NOW DUE 3/31/97.

GEORGIA INSTITUTE OF TECHNOLOGY
OFFICE OF CONTRACT ADMINISTRATION

NOTICE OF PROJECT CLOSEOUT

Closeout Notice Date 01/09/97

Project No. E-25-T72_____ Center No. 10/24-6-R8615-0A0_

Project Director BOOK W J_____ School/Lab MECH ENGR_____

Sponsor NATL SCIENCE FOUNDATION/GENERAL_____

Contract/Grant No. IRI-9526322_____ Contract Entity GTRC

Prime Contract No. _____

Title EXPLORATORY RESEARCH ON CONTROLLED PASSIVE HAPTIC DISPLAYS_____

Effective Completion Date 961231 (Performance) 970331 (Reports)

Closeout Actions Required:	Y/N	Date Submitted
Final Invoice or Copy of Final Invoice	N	_____
Final Report of Inventions and/or Subcontracts	N	_____
Government Property Inventory & Related Certificate	N	_____
Classified Material Certificate	N	_____
Release and Assignment	N	_____
Other _____	N	_____

Comments_____
LETTER OF CREDIT APPLIES. 98A SATISFIES PATENT REPORT._____

Subproject Under Main Project No. _____

Continues Project No. _____

Distribution Required:

Project Director	Y
Administrative Network Representative	Y
GTRI Accounting/Grants and Contracts	Y
Procurement/Supply Services	Y
Research Property Managment	Y
Research Security Services	N
Reports Coordinator (OCA)	Y
GTRC	Y
Project File	Y
Other _____	N
_____	N

E-25-T72
#1

OMB Number 3145-0058

NATIONAL SCIENCE FOUNDATION
4201 Wilson Blvd.
Arlington, VA 22230

PI/PD Name and Address

Book, Wayne J

Atlanta, GA 30332
United States

NATIONAL SCIENCE FOUNDATION
FINAL PROJECT REPORT

PART I - PROJECT IDENTIFICATION INFORMATION	
1. Program Official/Org.	*Georgia Tech Research Corporation - GA Institute of Technology*
2. Program Name	*ROBOTICS AND MACHINE INTELLIGE*
3. Award Dates	From: *07/15/95* To: *12/31/96*
4. Institution and Address	*Georgia Tech Research Corporation - GA Institute of Technology* *GA Tech Res Corp - GIT* *Administration Building* *Atlanta, GA 30332*
5. Award Number	*9526322*
6. Project Title	*Exploratory Research on Controlled Passive Haptic Displays*

NSF Grant Conditions (Article 17, GC-1, and Article 9, FDP-11) require submission of a Final Project Report (NSF Form 98A) to the NSF program officer no later than 90 days alter the expiration of the award. Final Project Reports for expired awards must be received before new awards can be made (NSF Grants Policy Manual Section 677).

Below, or on a separate page attached to this form, provide a summary of the completed projects and technical information. Be sure to include your name and award number on each separate page. See below for more instructions.

PART II - SUMMARY OF COMPLETED PROJECT (for public use)

The summary (about 200 words) must be self-contained and intelligible to a scientifically or technically literate reader. Without restating the project title, it should begin with a topic sentence stating the project's major thesis. The summary should include, if pertinent to the project being described, the following items:

- The primary objectives and scope of the project
- The techniques or approaches used only to the degree necessary for comprehension
- The findings and implications stated as concisely and informatively as possible

(See enclosed SUMMARY OF COMPLETED PROJECT)

PART III - TECHNICAL INFORMATION (for program management use)

List references to publications resulting from this award and briefly describe primary data, samples, physical collections, inventions, software, etc. created or gathered in the course of the research and, if appropriate, how they are being made available to the research community. Provide the NSF Invention Disclosure number for any invention.

(See enclosed TECHNICAL INFORMATION)

I certify to the best of my knowledge (1) the statements herein (excluding scientific hypotheses and scientific opinion) are true and complete, and (2) the text and graphics in this report as well as any accompanying publications or other documents, unless otherwise indicated, are the original work of the signatories or of individuals working under their supervision. I understand that willfully making a false statement or concealing a material fact in this report or any other communication submitted to NSF is a criminal offense (U.S. Code, Title 18, Section 1001).

Submitted via FastLane	
Principal Investigator/Project Director Signature	Date

IMPORTANT:
MAILING INSTRUCTIONS

Return this *entire* packet plus all attachments in the envelope attached to the back of this form. Please copy the information from Part I, Block I to the *Attention block* on the envelope.

PART IV -- FINAL PROJECT REPORT -- SUMMARY DATA ON PROJECT PERSONNEL

(To be submitted to cognizant Program Officer upon completion of project)

The data requested below are important for the development of a statistical profile on the personnel supported by Federal grants. The information on this part is solicited in response to Public Law 99-383 and 42 USC 1885C. All information provided will be treated as confidential and will be safeguarded in accordance with the provisions of the Privacy Act of 1974. You should submit a single copy of this part with each final project report. However, submission of the requested information is not mandatory and is not a precondition of future award(s). Check the "Decline to Provide Information" box below if you do not wish to provide the information.

Please enter the numbers of individuals supported under this grant.
Do not enter information for individuals working less than 40 hours in any calendar year.

	Senior Staff		Post-Doctorals		Graduate Students		Under-Graduates		Other Participants[1]	
	Male	Fem.	Male	Fem.	Male	Fem.	Male	Fem.	Male	Fem.
A. Total, U.S. Citizens	1			1						
B. Total, Permanent Residents										
U.S. Citizens or Permanent Residents[2]:										
American Indian or Alaskan Native										
Asian.....										
Black, Not of Hispanic Origin.....										
Hispanic										
Pacific Islander										
White, Not of Hispanic Origin	1			1						
C. Total, Other Non-U.S. Citizens										
Specify Country 1.										
2.										
3.										
D. Total, All participants (A + B + C)	1			1						
Disabled[3]										

☐ Decline to Provide Information: Check box if you do not wish to provide this information (you are still required to return this page along with Parts I-III).

[1] Category includes, for example, college and precollege teachers, conference and workshop participants.

[2] Use the category that best describes the ethnic/racial status for all U.S. Citizens and Non-citizens with Permanent Residency. *(If more than one category applies, use the one category that most closely reflects the person's recognition in the community.)*

[3] A person having a physical or mental impairment that substantially limits one or more major life activities; who has a record of such impairment; or who is regarded as having such impairment. *(Disabled individuals also should be counted under the appropriate ethnic/racial group unless they are classified as "Other Non-U.S. Citizens.")*

AMERICAN INDIAN OR ALASKAN NATIVE: A person having origins in any of the original peoples of North America and who maintains cultural identification through tribal affiliation or community recognition.

ASIAN: A person having origins in any of the original peoples of East Asia, Southeast Asia or the Indian subcontinent. This area includes, for example, China, India, Indonesia, Japan, Korea and Vietnam.

BLACK, NOT OF HISPANIC ORIGIN: A person having origins in any of the black racial groups of Africa.

HISPANIC: A person of Mexican, Puerto Rican, Cuban, Central or South American or other Spanish culture or origin, regardless of race.

PACIFIC ISLANDER: A person having origins in any of the orignal peoples of Hawaii; the U.S. Pacific territories of Guam, American Samoa, and the Northern Marinas; the U.S. Trust Territory of Palau; the islands of Micronesia and Melanesia; or the Philippines.

WHITE, NOT OF HISPANIC ORIGIN: A person having origins in any of the original peoples of Europe, North Africa, or the Middle East.

PART II - SUMMARY OF COMPLETED PROJECT

Active robotic devices can injure a user with sudden or unintended movements. A passive machine cannot initiate motion that could injure a user, but by programmably and selectively resisting user applied forces, it can (a) guide the user's motion and (b) provide the sensation of interaction with a virtual or remote environment. This exploratory project sought to establish this fact and devise the means by which successful implementation of these capabilities could be achieved and evaluated.

An experimental two degree of freedom arm actuated by two brakes and two clutches had been previously constructed. A brake will retard the motion of an axis of motion while a clutch couples the axes in either a direct or an inverting manner. To achieve the stated objective this device was modeled and then placed under computer control with several prospective algorithms. Performance has been measured for following simple paths and for displaying simple environments (a wall).

Two successful types of control algorithms were devised: (a) active impedance control with torque translation to feasible passive torques and (b) velocity based actuator selection with blending. Accurate path following and representative haptic displays of the environment were competing objectives, since accurate path following resulted in 'jerky' motion producing high and fluctuating accelerations. The tradeoffs involve selection of the algorithm and its parameters. Higher bandwidth actuators and the elimination of stiction will improve the experimental system.

PART III - TECHNICAL INFORMATION

References:

Book, W.J., Charles, R., Davis, H., Gomes, M., 'The Concept and Implementation of a Passive Trajectory Enhancing Robot,' American Society of Mechanical Engineers, DSC-Vol. 58, Proceedings of the ASME Dynamic Systems and Control Division, presented at the 1996 International Mechanical Engineering Congress and Exposition, Nov. 17-22, 1996, Atlanta, GA, pp.633-638.

Davis, H. and Book, W., 'Passive Torque Control of a Redundantly Actuated Manipulator,' to appear in Proceedings of the 1997 American Control Conference, June 4-6, 1997, Albuquerque, NM.

Davis, H.T., 'An Investigation of Passive Actuation for Trajectory Control,' M.S. Thesis, School of Mechanical Engineering, Georgia Institute of Technology, Atlanta, GA, June, 1996.

Gomes, M., 'An Examination of Control Algorithms for Dissipative Passive Haptic Interfaces,' M.S. Thesis under preparation, School of Mechanical Engineering, Georgia Institute of Technology, Atlanta, GA, expected March, 1997.

Description of results and their dissimination:

A patent application entitled 'Trajectory Guidance Apparatus and Method' Serial No. 08/401,742 was filed on March 9, 1995 on related concepts prior to the proposal of this research.

Software generated is specific to the hardware but the algorithms are described in the above referenced theses. Similarly, typical performance plots and data on the physical systems appear in these theses which are available through University Microfilms. A description of the work is available on the World Wide Web at http://davinci.marc.gatech.edu/