QUARTERLY PROGRESS REPORT

PROJECT THEMIS

STUDIES IN DIGITAL AUTOMATA
BY THE
COLLEGE OF ENGINEERING
LOUISIANA STATE UNIVERSITY
BATON ROUGE, LOUISIANA 70803

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February 29, 1972

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STUDIES IN DIGITAL AUTOMATA

Scientific Interim

Dr. Paul Murrill

February 1972

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The period December 1, 1971 through February 29, 1972 is covered in this progress report. The first section presents summaries of the progress on the various research topics currently being pursued.
Abstract

The period December 1, 1971 through February 29, 1972 is covered in this progress report. The first four sections comprise an up-to-date list of publications, presentations, and reports. The final section presents summaries of the progress on the various research topics currently being pursued.
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Publications

The following is an up-to-date list of presentations, publications, and technical reports arising from work under the Project THEMIS program at Louisiana State University.
JOURNAL PUBLICATIONS


* These reports are contained in AD 696712, AFOSR 69-2737TR.
JOURNAL PUBLICATIONS (Continued)


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JOURNAL PUBLICATIONS (Continued)


PAPERS PRESENTED AT MEETINGS


LSU-T-M7 "Use of Search Techniques to Determine Optimal Switching Times", J. A. Miller, C. L. Smith, and P. W. Murrill, presented at the 64th National AIChE Meeting, New Orleans, March 16-20, 1969, AD 687131, AFOSR 69-1408TR.


LSU-T-M14 "Hybrid Computation at Louisiana State University", by A. B. Corripio, presented at the annual meeting of the Southeastern Section of the Analog/Hybrid Computers Educational Users Group, Clemson, South Carolina, November 6, 15-9, AD 705362, AFOSR 70-1092TR.


LSU-T-M16 "Application of Simulation in the 70's" by E. C. Tacker, presented at the Southwestern Simulation Council Meeting at the Manned Spacecraft Center in Houston, Texas, September 19, 1969.


TECHNICAL REPORTS

A. Submitted to Project Administrator Only


LSU-T-SR3 Analog Simulation of Induced Disturbances on Feedback Control Systems, Mario J. Caluda, M.S. Thesis, Department of Mechanical Engineering, Louisiana State University, Baton Rouge, August 1968.


LSU-T-SR6 Stochastic Control of Chemical Processes, Brian Ramaker, Ph.D. Dissertation, Department of Chemical Engineering, Louisiana State University, Baton Rouge, August, 1968.


LSU-T-SR12 Fourier Transforms for System Identification, Carlos Ray Dollar, Ph.D. Dissertation, Department of Chemical Engineering, Louisiana State University, Baton Rouge, August 1969.

LSU-T-SR13 Control of Batch Crystallization, E. J. Lui, M.S. Thesis, Department of Chemical Engineering, Louisiana State University, Baton Rouge, August 1969.

LSU-T-SR14 Applying Feedback and Feedforward Control, J. A. Miller, Ph.D. Dissertation, Department of Chemical Engineering, Louisiana State University, Baton Rouge, January, 1970, AD 696147, AFOSR 69-2727TR.


LSU-T-SR17 Digital Control of Processes, A. B. Corripio, Ph.D. Dissertation, Department of Chemical Engineering, Louisiana State University, Baton Rouge, Louisiana, January 1970, AD 702872, AFOSR 70-0729TR.

LSU-T-SR18 Trajectory Optimization by the Method of Steepest Descent, Mahmoud Tabandeh, Department of Electrical Engineering, Louisiana State University, Baton Rouge, June 1969.


LSU-T-SR24 Analog Simulation of a 15th Order Rate Control Loop With Widely Separated Eigenvalues, C. C. Lee, C. W. Sanders, P. M. Julich, and E. C Tacker, Departments of Electrical and Chemical Engineering, Louisiana State University, Baton Rouge, Louisiana, April 1971.


B. General Distribution


LSU-T-TR-7 "Development of Predictor Models", by B. L. Ramaker, C. L. Smith, and P. W. Murrill, AD 688797, AFOSR 69-1416TR.


LSU-T-TR-12 "Formulating the Least Square Regression for Continuous Analysis", C. F. Moore, C. L. Smith, and P. W. Murrill, AD 688803, AFOSR 69-1421TR.


LSU-T-TR-16 "Controlling a Very Noisy System", B. L. Ramaker, C. L. Smith, and P. W. Murrill, AD 688806, AFOSR 69-1425TR.


LSU-T-TR-20 "Improving Controller Settings Based on Open Loop Methods", J. H. Dube, C. L. Smith, and P. W. Murrill, July 1969, AD 694044, AFOSR 69-2380TR.


LSU-T-TR-24 "Effects of Parameter Variations on the Capability of a Proportional Navigation Missile Against an Optimally Evading Target in the Horizontal Plane", by Paul M. Julich and David A. Borg, October 1969, AD 700099, AFOSR 70-0085TR.

LSU-T-TR-25 "Proportional Navigation vs. an Optimally Evading Constant Speed Target in Two Dimensions", by Paul M. Julich and David A. Borg, October 1969, AD 702821, AFOSR 70-0727TR.

LSU-T-TR-26 "Approximate Currents for Circular Arrays of Radial and Tangential Dipoles", by John L. Hilburn, October 1969, AD 700098, AFOSR 70-0086TR.


LSU-T-TR-33 "An Air to Surface Missile Simulation Using a Digital Simulation Language", by G. D. Whitehouse, Mario Caluda, and A. J. McPhate, December 1969, AD 70208, AFOSR 70-0600TR.


LSU-T-TR-43 "Discrete Model Identification Based on Correlation Functions", Brian Froisy, Cecil Smith, and Armando Corripio, January 1971, AD 718995, AFOSR 71-0361TR.


PROGRESS REPORTS

LSU-T-PR1 November 30, 1967, Quarterly Progress Report
LSU-T-PR2 February 29, 1968, Quarterly Progress Report
LSU-T-PR3 May 31, 1968, Quarterly Progress Report
LSU-T-PR4 August 31, 1968, Quarterly Progress Report
LSU-T-PR5 November 30, 1968, Quarterly Progress Report
LSU-T-PR6 February 28, 1969, Quarterly Progress Report
LSU-T-PR7 May 31, 1969, Quarterly Progress Report
LSU-T-PR8 August 31, 1969, Quarterly Progress Report
LSU-T-PR9 November 30, 1969, Quarterly Progress Report
LSU-T-PR10 February 28, 1970, Quarterly Progress Report
LSU-T-PR11 May 31, 1970, Quarterly Progress Report
LSU-T-PR12 August 31, 1970, Quarterly Progress Report
LSU-T-PR13 November 30, 1970, Quarterly Progress Report
LSU-T-PR14 February 28, 1971, Quarterly Progress Report
LSU-T-PR15 May 31, 1971, Quarterly Progress Report
LSU-T-PR16 August 31, 1971, Quarterly Progress Report
LSU-T-PR17 November 30, 1971, Quarterly Progress Report
Progress Reports

The following reports cover the progress made by individual investigators during the past quarter.
Project Director: J. A. Planchard
Graduate Student: Mohamad Karbassian
Project Title: Application of the Principle of Invariance to a Distributed Parameter System

The object of this study is to determine whether existing identification techniques can be utilized on systems described by partial differential equations in order to apply advanced control methodology such as the principle of invariance.

The system chosen for study is a shell and tube heat exchanger in which the control objective is to maintain the existing concentration of H₂O in a hydrogen stream on the face of upsets in the entering stream concentration and temperature.

The analytical frequency response of this system has been determined and compared to that obtained utilizing a Taylor diffusional model. The results indicate that the Taylor diffusional model is not a valid representation of the system.

A stochastic identification procedure will also be utilized to model the system.
Project Director: J. A. Planciard

Graduate Students: T. Perkins and J. Barzinji

Project Title: Modeling the Human Operator in a Tracking Task

A two node human operator model (tracking and acquisition) has been successfully developed that predicts the mean performance of a human operator in a compensatory tracking task. Data for verification of the model was obtained by utilizing the real time capability of the LSU hybrid computer.

Correlations are presently being developed to predict the variance of the operator in terms of certain key parameters of the system.
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Project Director: J. A. Planchard
Graduate Student: Ahmad Shariat
Project Title: The Optimal Control of a Distributed Parameter System

This project has been completed and the dissertation mailed to the Themis technical monitor. A Themis report summarizing the work is being prepared.
Project Directors: A. B. Corripio and C. L. Smith
Graduate Student: Frank T. Davis
Project Title: The Simulation of Large Industrial Centrifugal Compressors

An unsteady-state model of a constant speed centrifugal compressor has been developed and programmed on the IBM-360 utilizing CSMP and on the XDS-15 utilizing SLI. The model includes suction throttling for discharge pressure control and bypass for surge control. It is based upon design data obtained from one of the major manufacturers of centrifugal compressors. A paper is being completed for presentation at the Third Annual Pittsburgh Modeling and Simulation Conference on April 24 and 25 of 1972.

The Enjay Chemical Company has released the design information necessary to model a variable speed centrifugal compressor and its associated steam turbine driver. The information should be forthcoming from Dresser Industries and General Electric as they have been awaiting the release from Enjay. This information will be utilized to develop the variable speed centrifugal compressor model.

This project is nearing completion with the expected completion date being June 1, 1972.
Project Director: P. M. Julich
Graduate Students: D. A. Borg and D. K. Jones *
Project Title: Simulation and Analysis of a Stiff Control System
Originating Organization: Air Force Weapon Laboratory
Kirtland Air Force Base, N. M.

Efforts are being made by David Jones to serially simulate the two axes of the system under consideration. This is necessary because of the limited equipment available on the EAI 680. The changes in the elevation axis simulation requested by personnel at Kirtland have been completed and checked out. David Borg is working on a method for systematically designing digital compensation for the system. It is necessary to develop high accuracy methods of operation on the digital computer to avoid serious roundoff errors. The development of these methods has been partially completed during the report period.

Design of a bang-bang controller continues. Switching surfaces to give a reasonable overshoot have been obtained since the last progress report but effort continues because the inner and outer azimuth's still do not track each other close enough to avoid upsetting the gyro's.

* 2nd. Lieutenant on active duty with Air Force stationed at LSU.
Project Director: P. M. Julich
Graduate Students: T. Reddoch and George Buchert
Project Title: Optimization of Interconnected Control Systems

This project is a continuing study of multivariable control methods applied to control systems which are interconnected. Studies of symmetry of the cost function and resulting control strategy have been made. Comparisons of control laws designed for independent systems which are then interconnected have been made with results obtained from optimizing the overall system.

A method for implementing the parameter optimization algorithm proposed by Athans and Levine has been programmed by George Buchert. Problems were encountered initially because of convergence difficulties. These problems have been solved during the past report period however and the method is operational. This method will be compared with results obtained from solution of matrix Riccati equation which requires feedback of all control variables.

A paper applying the results of this work to interconnected power control systems will be presented April 11 at IEEE Region III Meeting in Knoxville, Tennessee.
Project Director: P. M. Julich
Graduate Student: Charles Ward*
Project Title: Guidance Laws for Interception of Optimally Evading Targets

This project is a continuation of studies into modification of proportional navigation systems to improve the capability of intercepting an optimally evading target. Earlier studies pointed out some inherent weaknesses of proportional navigation against maneuvering targets. Earlier studies showed that proportional plus pursuit navigation might result in improved capture capability. This study is examining proportional plus pursuit navigation against optimally evading targets in the horizontal plane.

* 2nd. Lieutenant on active duty with USAF; stationed at LSU.

Project Director: Edgar C. Tacker
Graduate Student: Chi C. Lee*
Project Title: Optimization of Interconnected Power Systems - The Load Frequency Control Problem

We have now compiled a number of cases wherein stochastic controllers using our model formulation significantly out perform deterministic optimal controllers. Our results thus far appear (or will appear) in the references given below.

References


* Supported by the LSU Division of Engineering Research and the Department of Electrical Engineering.
Project Director: Edgar C. Tacker

Graduate Students: Thomas D. Linton and Charles W. Sanders, Jr.*

Project Title: Computational Aspects of Functional Space-Derived Optimal Stochastic Controllers

Further results have been obtained for the problem described in the May 31, 1971 Progress Report both in the open-loop case and for a quasi-closed-loop controller. These results will be reported in a future Themis report as well as in References 1 - 5.

References


* Supported by an NSF Traineeship and the Department of Electrical Engineering