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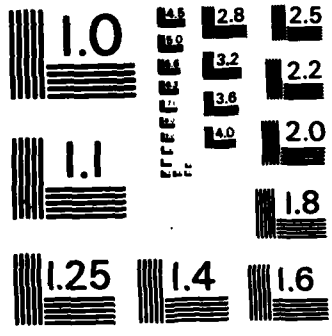

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Research was continued on the study of error detecting and error correcting codes for achieving the reliable transmission or storage of information over a noisy communications channel an imperfect memory. Three specific research areas were investigated. They were:

(1) The design and performance evaluation of error detecting codes.
(2) Decoding strategies for redundant discrete Fourier transform codes and their applications to impulse noise cancellation.
(3) Coding and decoding of convolutional codes.

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Annual Scientific Report

AFOSR-82-0061

"A Study of Error Detection and Correction Codes"

for the period

February 1, 1983 to January 31, 1984

Jack Keil Wolf
Department of Electrical and Computer Engineering
University of Massachusetts
Amherst, MA 01003

Abstract

Research was continued on the study of error detecting and error correcting codes for achieving the reliable transmission or storage of information over a noisy communications channel or imperfect memory. Three specific research areas were investigated. ~~They~~ Those were:

(1) The design and performance evaluation of error detecting codes.

(2) Decoding strategies for redundant discrete Fourier transform codes and their applications to impulse noise cancellation.

(3) Coding and decoding of convolutional codes.

Research Objectives

This was the second year of the research effort studying various means for achieving the reliable transmission or storage of information over noisy communication channels or imperfect memories. In the first year, the principle research topic was the study of error detection codes. This work was continued during the second year. In addition, two other research objectives were explored. The first of these objectives was to find effective means for protecting discrete-time analog (i.e. continuous-amplitude) corrupted by an impulsive noise environment. The second of these objectives was to explore convolutional codes and their relationships with block codes and to explore the relationship between convolutional codes and signal designs.

Status of Research Effort

The research on error detection codes was completed during the first quarter of the current year's effort. The work was reported in an M.S. dissertation [1] and in a journal publication [6]. Specifically, the journal publication presented a proof that codes that do not satisfy the Varsharmov-Gilbert bound have the property that their probability of undetected error exceeds $\exp_2(-$ # of parity symbols) for some value of channel error probability less than one-half. The importance of this result is that a commonly used bound for the error detection capability of codes <u>is not true</u> for most long codes since almost all long codes except some very special high or low rates do not satisfy the Varsharmov-Gilbert bound.

Much progress was made on the subject of coding for discrete-time, continuous amplitude signals. A class of codes based upon the discrete Fourier Transform was investigated and the efficacy of these codes for

transmission of information over an impulsive noise channel was studied. The results of this research were reported in two conference papers [4-5] (one invited [5]) and a journal article [2]. An M.S. dissertation also was completed on this subject [3].

Work was initiated on a project which treats convolutional codes and block codes in a common framework. This work is currently in progress and no papers on this work have yet been submitted. The basic theme of this work is that one can use the initial state of a convolutional encoder to carry information and then force the encoder to end in that same state. Used in this manner the convolutional code beomes a quasi-cyclic block code. Decoding algorithms have been developed for this coding scheme. Since these decoding algorithms work for both hard and soft decisions, this technique presents an attractive method for soft decision decoding of all quasi-cyclic codes. Furthermore, this common framework was used to find new convolutional codes from quasi-cyclic block codes and new block codes from convolutional codes. This appears to be a very attractive research area.

A study of another application of convolutional codes was also initiated. Here we begin with the work of Ungerboeck (G. Ungerboeck, "Channel Coding with Multilevel/Phase Signals," IEEE Trans. on Information Theory, vol. IT-28, pp. 55-67, Jan. 1982) who used amplitude and phase modulation to improve the performance of signal designs without sacrificing data rate or increasing bandwidth. We have generalized his approach to the case where we use amplitude, phase and frequency modulation. Preliminary results were extremely encouraging with improved performance over Ungerboeck's codes. No publications yet have been prepared on this subject.

Chronological List of Publications

1. Roberto Padovani, The Probability of Undetected Error for Linear Block Codes, M.S. Thesis, University of Massachusetts, Department of Electrical and Computer Engineering, January, 1983.

2. Jack Keil Wolf, "Redundancy, the Discrete Fourier Transform and Impulse Noise Cancellation," IEEE Transactions on Communications, vol. COM-31, pp. 458-461, March, 1983.

3. Thomas Philips, Error Correcting Codes Based on the Discrete Fourier Transform, M.S. Thesis, University of Massachusetts, Department of Electrical and Computer Engineering, April, 1983.

4. Jack Keil Wolf and Thomas Philips, "The Detection and Estimation of a Single Impulse Using the Discrete Fourier Transform," Proceedings of the Ninth Symposium on Signal Processing, Nice, France, May, 1983.

5. Jack Keil Wolf, "Analog Codes," ICC 83 Conference Record, Boston, Massachusetts, June, 1983 (invited paper).

6. Roberto Padovani and Jack Keil Wolf, "Poor Error Correction Codes are Poor Error Detecting Codes," IEEE Trans. on Information Theory, vol. IT-30, pp. 110-111, January, 1984.

List of Personnel

Jack Keil Wolf, Professor of Electrical and Computer Engineering

Evaggelos Geraniotis, Assistant Professor of Electrical and Computer Engineering

Howard Ma, Ph.D. Candidate

Roberto Padovani, Ph.D. Candidate

Thomas Philips, M.S. Candidate*

Wenlong Zhang, Ph.D. Candidate

*Thomas Philips completed his M.S. dissertation entitled, "Error Correcting Codes Based On the Discrete Fourier Transform" in April, 1983, and was granted the M.S. degree in May, 1983.

Interactions

1. Jack Keil Wolf continued as a member of the Committee on Review of National Cmmunication System Initiatives in Support of National Telecommunication Policy, Board on Telecommunications - Computer Applications, Commission on Engineering and Technical Systems, National Research Council. This committee was asked to review initiatives of the NCS in support of national security telecommunications policy to provide survivable, endurable communications for the national government under a variety of emergency conditions.

2. Jack Keil Wolf has given a number of invited talks at various universities and technical meetings. These include:

   U.C. Berkeley, California, February 4, 1983, February 7, 1983
   Rice University, Houston, Texas, February 9, 1983.

3. Jack Keil Wolf is a consultant on several D.O.D. sponsored induatrial contracts.

4. Jack Keil Wolf is a member of the Board of Governors of the Information Theory Group of IEEE. He is also international chairman of Commission C of URSI.

5. Jack Keil Wolf was awarded a Faculty Research Grant by the University of Massachusetts. This grant relieved Professor Wolf of his teaching assignments for the calendar year 1983. Professor Wolf spent a portion of this time visiting other institutions. In particular he was a Visiting Scientist at IBM Zurich where he worked with Dr. Ungerboeck to learn the details of his error control/signal design scheme which is part of this research effort.