LAWRENCE
LIVERMORE
NATIONAL
LABORATORY

LLNL-TR-745082

Advanced Analog Signal Processing for Fuzing Final Report CRADA No. TC-1306-96

C. Y. Fu, D. Spencer

January 24, 2018

Disclaimer

This document was prepared as an account of work sponsored by an agency of the United States government. Neither the United States government nor Lawrence Livermore National Security, LLC, nor any of their employees makes any warranty, expressed or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States government or Lawrence Livermore National Security, LLC. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States government or Lawrence Livermore National Security, LLC, and shall not be used for advertising or product endorsement purposes.

This work performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under Contract DE-AC52-07NA27344.

DISCLAIMER

Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.

ADVANCED ANALOG SIGNAL PROCESSING FOR FUZING

Final Report
CRADA No. TC-1306-96

Date: November 17, 1999 Revision: 1

A. Parties

The project was a CRADA between the Lawrence Livermore National Laboratory (LLNL) and Kaman Aerospace Corporation/Raymond Engineering Operations.

University of California
Lawrence Livermore National Laboratory
7000 East Avenue, L-271
Livermore, CA 94550
Chi Yung Fu, (925) 423-1175

Raymond Engineering
217 Smith Street
Middletown, CT 06457
Dale Spencer, (860) 632-4477

B. Project Scope

The purpose of this CRADA between LLNL and Kaman Aerospace/Raymond Engineering Operations (Raymond) was to demonstrate the feasibility of using Analog/Digital Neural Network (ANN) Technology for advanced signal processing, fuzing, and other applications.

This cooperation sought to leverage the expertise and capabilities of both parties--Raymond to develop the signature recognition hardware system, using Raymond's extensive experience in the area of system development plus Raymond's knowledge of military applications, and LLNL to apply ANN and related technologies to an area of significant interest to the United States government.

This CRADA effort was anticipated to be a three-year project consisting of three phases: Phase I, Proof-of-Principle Demonstration; Phase II, Proof-of-Design, involving the development of a form-factored integrated sensor and ANN technology processor; and Phase III, Final Design and Release of the integrated sensor and ANN fabrication process.

Under Phase I, to be conducted during calendar year 1996, Raymond was to deliver to LLNL an architecture (design) for an ANN chip. LLNL was to translate the design into a stepper mask and to produce and test a prototype chip from the Raymond design.

The ANN chip architecture was not delivered to LLNL, and consequently no significant work was carried out under Phase I during 1996. Conduct of Phases II and III was contingent on the Parties obtaining additional funding during calendar year 1997 from a federal sponsor. This funding was not forthcoming, and CRADA work was discontinued.

C. Technical Accomplishments

LLNL demonstrated a neural net integrated circuit with 31 of 32 neurons functioning. Evaluation testing of proof-of-principle test wafers identified four areas for improvement:

1. Input bias offset measured on internal neuron amplifiers was 100 mV more than the desired 50 mV level.

2. Neuron gain control was not performing as desired due to process control problems. The short term fix found for this was to use unity gain internally and compensate externally.

3. Extension shaping was not as desired.

4. Wafer Yield was below predicted levels due to foundry process control problems. Only three of nine wafers delivered to LLNL were usable and those were marginal.

Raymond developed a Neural Network hardware test bed, simulations of a 32 neuron neural network and the predicted weights to implement the Raymond Media Determination Algorithm in the LLNL neural network IC chip. Final implementation of the weights into the neural network IC was not undertaken due to the high risk associated with the external foundry (ORBIT Semiconductor) process problems and the high cost of porting the design to a new foundry. Researchers remain convinced that the problems left unresolved were more production process oriented than theoretical and conclude that the approach remains technically sound. Given that originally the neural network chip was expected to be fully debugged in 10 runs and that the project had to stop after the second run due to lack of sufficient funding, the researchers believe that the project already performed better than expected.

No LLNL or Raymond deliverables were accomplished for this project.

D. Expected Economic Impact

This project was discontinued early in Phase I. As a result, this CRADA project by itself is expected to have almost no economic impact in the commercial sector. If the project could have been carried through to completion there would have been greater potential for the commercial application of neural network technology to signal processing.

E. Partner Contribution

Participant developed a breadboard for the ANN chip to be developed by LLNL during Phase I.

F. Documents/Reference List

A. Publications: None

B. Subject Inventions:

LLNL Subject Inventions: None

Participant Subject Inventions: None Reported

G. Acknowledgment

Participant's signature of the final report indicates the following:

1) The Participant has reviewed the final report and concurs with the statements made therein.

2) The Participant agrees that any modifications or changes from the initial proposal were discussed and agreed to during the term of the project.

3) The Participant certifies that:
   a) all reports either completed or in process are listed, and
   b) all Subject Inventions attributable to the project have been disclosed or are included in a list attached to this report.

4) The Participant certifies that if tangible personal property was exchanged during the agreement, all has either been returned to the initial custodian or transferred permanently.

5) The Participant certifies that its Proprietary Information has been returned or destroyed by LLNL.

11/30/99 — Dale Spencer, Date
Kaman Aerospace Corporation
Raymond Engineering Operations

12/8/99 — Chi Yung Fu, Date
Lawrence Livermore National Laboratory