Tuskegee University

Founded by Booker T. Washington

Identification of Surface and Near Surface Defects and Damage Evaluation by Laser Speckle Techniques

NAG-1-1865

Summary of Research

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NASA Langley Research Center

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SUMMARY

As a part of the grant activity, a laboratory was established within the Department of Electrical Engineering for the study for measurements of surface defects and damage evaluation. This facility has been utilized for implementing several algorithms for accurate measurements of defects. Experiments were conducted using simulated images and multiple images were fused to achieve accurate measurements.

During the nine months of the grants when the principal investigator was transferred in my name, experiments were conducted using simulated synthetic aperture radar (SAR) images. This proved useful when several algorithms were used on images of smooth objects with minor deformalities. Given the time constraint, the derived algorithms could not be applied to actual images of smooth objects with minor abnormalities.

In addition, five undergraduate and three graduate students were given student wages and three student's tuition fees were paid using the grant. These students conducted various experiments in the communication laboratory which was presented as their senior design project. A complete list of African-American students who benefited from this grant can be found in Appendix I.

Note: Many unsuccessful attempts were made to contact (through phone, fax and email) Dr. Mohamed A. Seif who was the original principal investigator during the first three years. This was done in order to get a project report and summary of research on the work he did during the first three years. However, he did not return my calls or emails. Hence, the summary presented here is for the last nine months of the grant during which I was the principal investigator. A copy of one of the email I sent is attached.

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COMMUNICATION AND IMAGE PROCESSING FACILITY
ROOM 406, ENGINEERING BUILDING
TUSKEGEE UNIVERSITY

OBJECTIVE:

The primary goal is to teach a laboratory course along with the course EENG 0538, Communication Theory. The desired course EENG 538L, Communication Laboratory will focus on conducting experiments in both analog and digital modulation. The students will learn to design Transmitters and Receivers using different types of modulation schemes for various communication systems. The course outcome and course outline is given below.

COURSE OUTCOMES:

	EXPECTED LEVEL OF COMPETENCE			
	Basic Skills	Application Skills	Analytical Skills	Design Skills
1. Understand Analog Modulated Circuit		x	x	
2. Understand Frequency Modulated Circuits		x	x	
3. Understand Phase Modulated Circuits		x	x	
4. Design Multiple Access Circuits		x	x	x

COURSE OUTLINE:

Experiment #1: Amplitude Modulator

Experiment #2: Balanced Modulator

Experiment #3: Super heterodyne Receivers

Experiment #4: Frequency Modulator

Experiment #5: Frequency Demodulator

Experiment #6: Pulse Modulator

Experiment #7: Multiplexing

Experiment #8: Transmission Lines

A detailed description is given in the attached manual.

LABORATORY EQUIPMENTS:

The core facilities available in the communication laboratory, which include oscilloscopes, digital multimeters, power supplies, and network analyzers, was established with the help of a generous grant from Hewlett Packard (HP). Additional equipments were added with the help of the Department of Electrical Engineering and a NASA Langley Research Grant in which I was the principal investigator. A complete list of the equipments is given below.

Item #	Equipments	Units
1	HP Vectra VL6 PC	4
2	HP M900 Color Monitor	4
3	HP Oscilloscope	2
4	HP Power Supply	2
5	HP Network Analyzer	2
6	HP Signal Analyzer	2
7	Breadboard	5
8	3COM Wireless Kit	1
9	Healthkit Communication Kit	4

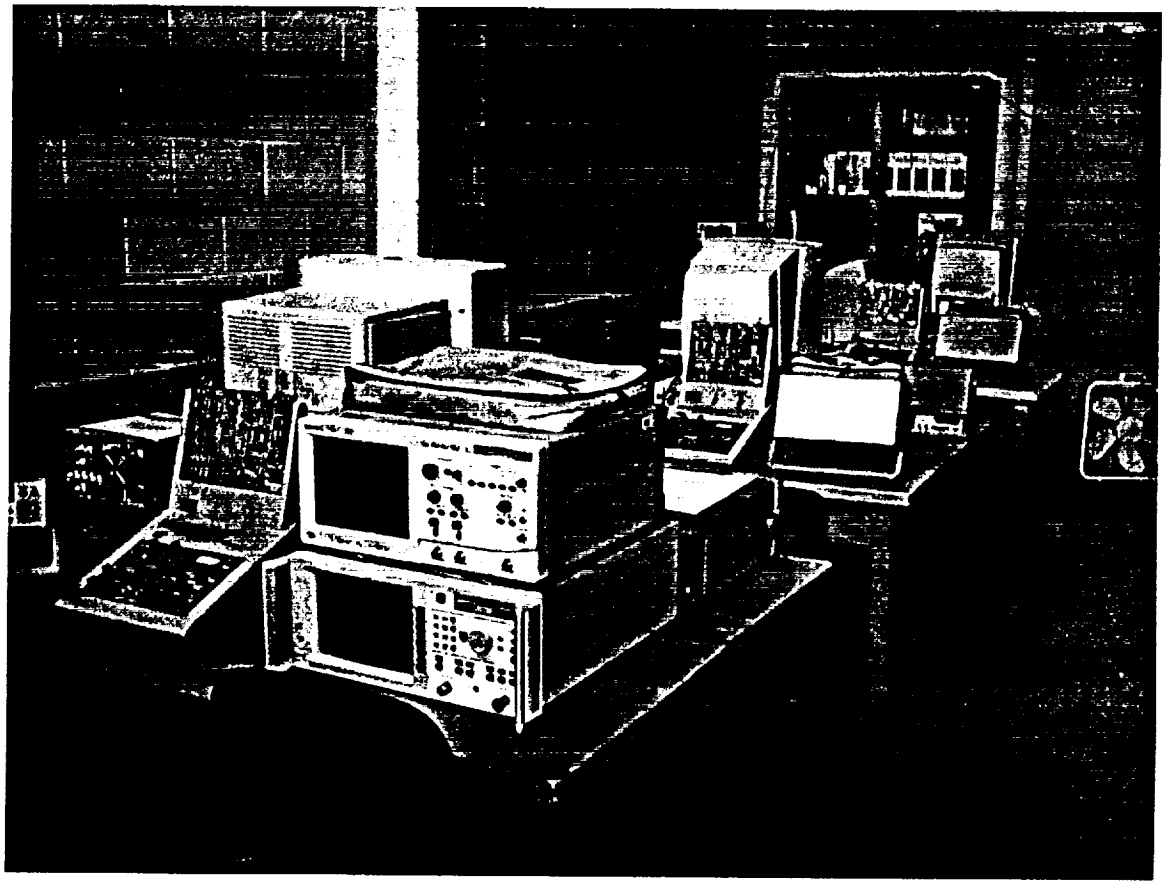


Figure 1: The left side of the Communication Laboratory ENBL 406

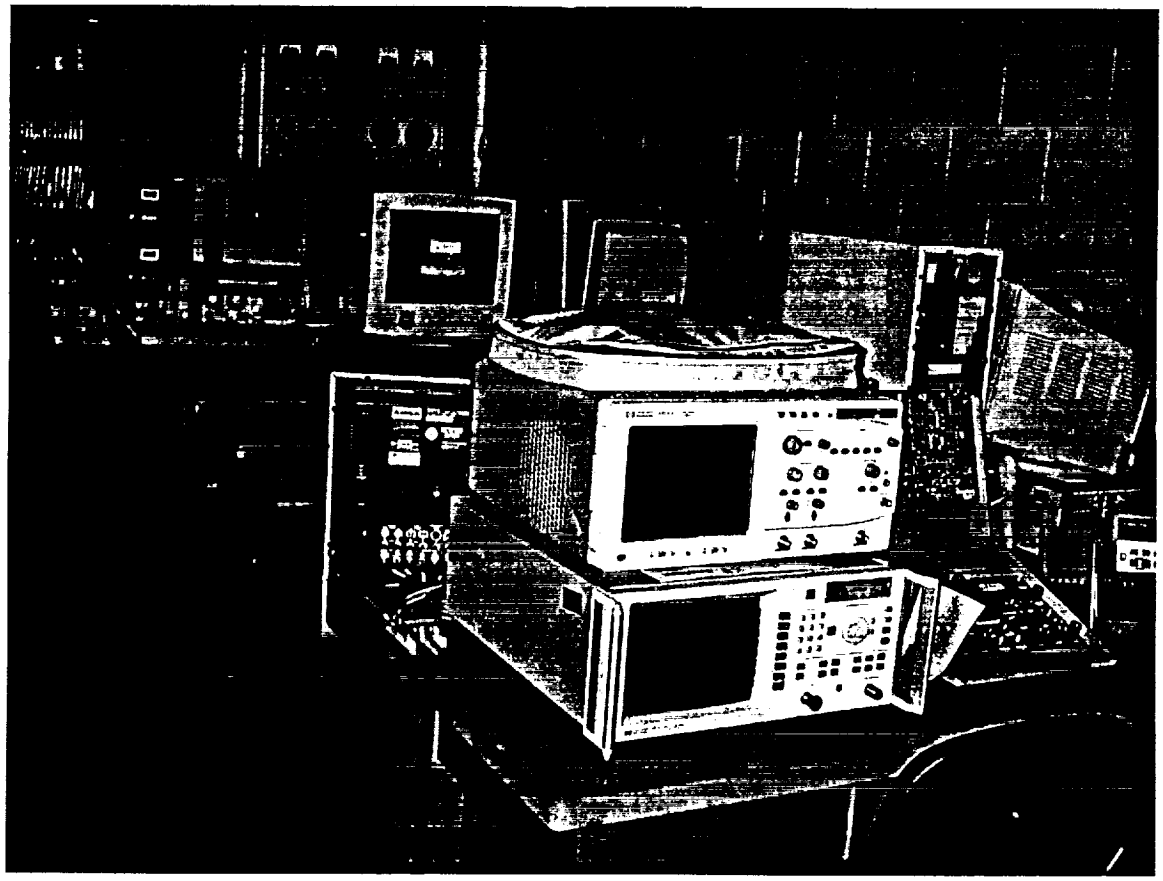


Figure 2: The right side of the Communication Laboratory ENBL 406

RESEARCH CONDUCTED

During the nine months of the grants when the principal investigator was transferred in my name, experiments were conducted using simulated synthetic aperture radar (SAR) images. This proved useful when several algorithms were used on images of smooth objects with minor deformalities. Given the time constraint, the derived algorithms could not be applied to actual images of smooth objects with minor abnormalities.

In addition, five undergraduate and three graduate students were given student wages and two student's tuition fees were paid using the grant. These students conducted various experiments in the communication laboratory which was presented as their senior design project.

Fusion of Simulated Synthetic Aperture Radar Image

The importance of imaging sensors for Earth's observations is well established and planetary missions have also benefited from use of such systems. Synthetic aperture radar (SAR) is a coherent imaging sensor. It has an all-weather day and night imaging capabilities coupled with the achievable high resolutions make it fundamental instrument for earth and other planet observation. SAR systems involve large data volumes with extensive processing to achieve the images with the required resolutions. A drastic increase of computer accessible memory and computing power has propelled design and implementation of algorithms for digital SAR data processing. Our project involves fusion of digital data images with minimum processing time and cleansing of multiple noise images using various order statistic algorithms.

As mentioned above the SAR image data from the satellite is processed these days, with the help of computers using complex algorithms to discern the image/data received by the satellite.

We have tried to simulate such kind of a data with the help of data files(256 by 256 matrix images), which represent some earth area under view by a satellite (Image. 1). It has some man-made object including some airplanes, battle tanks and some buildings. We have tried to fuse three similar looking data files, with some artificially generated noise in them.

We have fused these files with the help of simple algorithms like finding the maximum of each element in the files and generating a single max data file. Also we have found the mean and minimum of the elements of data files in a similar way.

We have also demonstrated that if each data file is divided into 16 different data files, and then the fusion is done, then the amount of processing time for a serial machine on a PC or Unix platform is reduced considerably.

Also, if the processing is done using dynamic memory allocation, the amount of processing time is again reduced considerably.

We also attempted to process the data files with the help of distributed computing available on campus. We, thus, used MPI (Message Passing Interface) to solve the same problem to see if there was any performance improvement in term of processing time. But we were unable to get any desired results in this case.

In the second part of our project we created 10 different randomly generated images, using rand() and srand () functions in C programming. We then fused the images using different order statistics, like taking the mean of middle four terms after the sorting in ascending order had been done. An ordered mean can be represented as

Ordered mean: $m(k_1, k_2) = \sum_{k=k_1}^{k_2} \frac{X_{(k)}}{k_2 - k_1 + 1}$

By changing the values of k_1 and k_2 we can achieve different ordered mean.

Image 1: This is the original image that we started with and it shows a general view of a military/Air Force base.

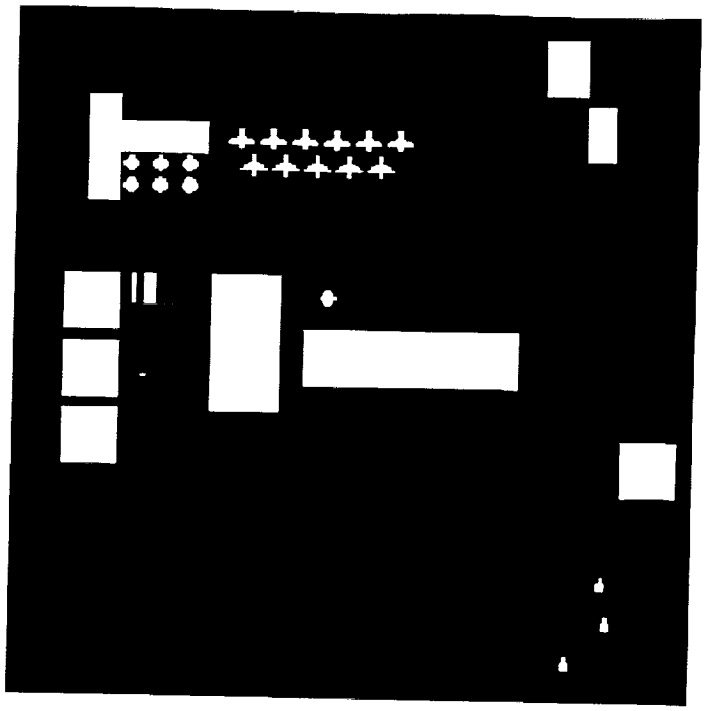


Image 1

The white pixels represent 1's of the matrix and the black pixels represent 0's. This image was formed using 256 by 256 matrix being processed in Matlab.

Image 2: This collection of images shows first 12 of the 16 different images that we divided the original image to, in order to reduce the processing time:

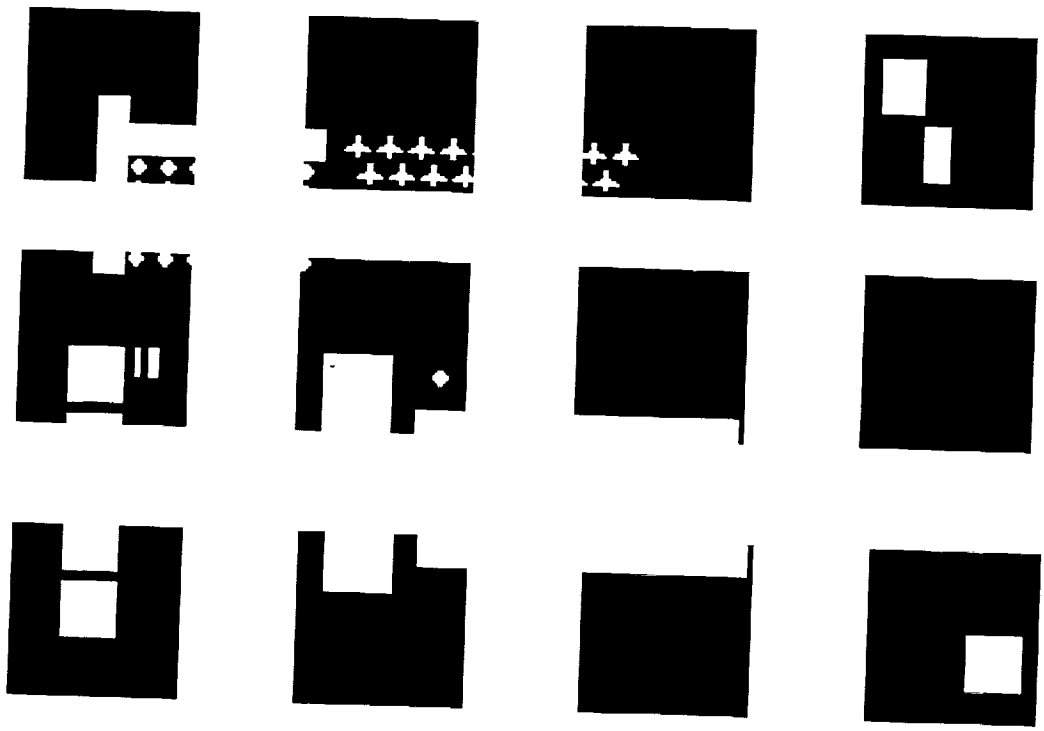


Image 2

It is to be noted that there were two other similar images, with some minor pixel differences, which were divided in a similar fashion and then fused. The calculation of processing time was done on these images and was found to be less than for processing time if had not divided the images.

Image 3: Given below are a selected few noise images created using rand() and srand() functions of the C programming code with the random function seeded with the system time. A total of 10 noise images were used for this project.

first noise image with 0.1 noise

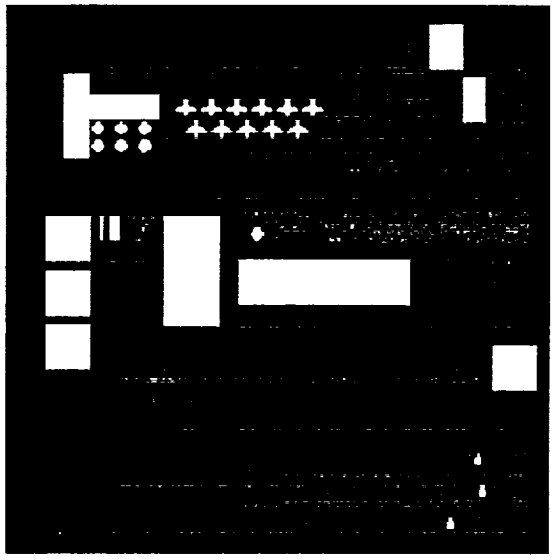


Image 3(a)

second noise image with 0.1 uniform dis. noise

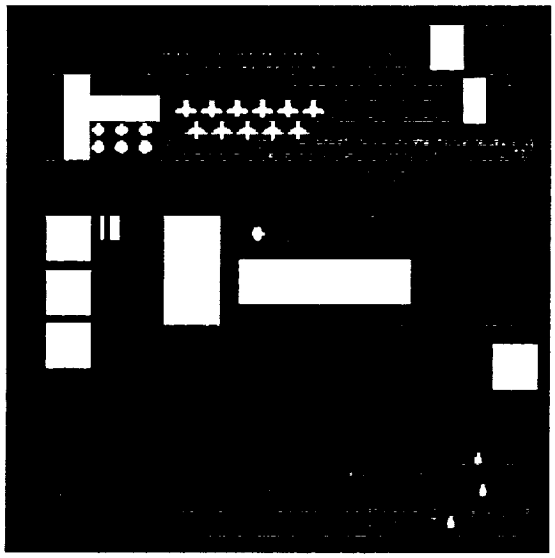


Image 3(b)

RESULTS

The times on serial m/c (HP Kayak Pentium III) using VC++ as compiler
were:
1) 0.84 seconds, for the three 256 X 256 SAR files (without using the Dynamic Memory Allocation- DMA).
2) 0.768 seconds, for the 3 X 16 -> 64 X 64 SAR files (without using the DMA). .
3) 0.23 seconds, for the three 256 X 256 SAR files (using the DMA).
4) 0.20 seconds, for the 3 X 16 -> 64 X 64 SAR files (using the DMA).

The times on the Unix machines using a serial processor:
1) 0.86 seconds, for the three 256 X 256 SAR files (using the DMA).
2) 0.57 seconds, for the 3 X 16 -> 64 X 64 SAR files (using the DMA).

The noise images were processed/cleaned/filtered and a sample of the image results is shown.

Image filtering using order statistics

Given below is a sample result of our processing of images in C programs. Different order statistics were used to clean the images given in Chapter 2, the explanation and order statistics used are given with the images.

This image was generated using the order statistics for 10 different noise images. Here the mean of middle 4 elements X(4), X(5), X(6), X(7) of maximum ordered array generated from each noise image matrix was taken and the image was generated using Matlab.

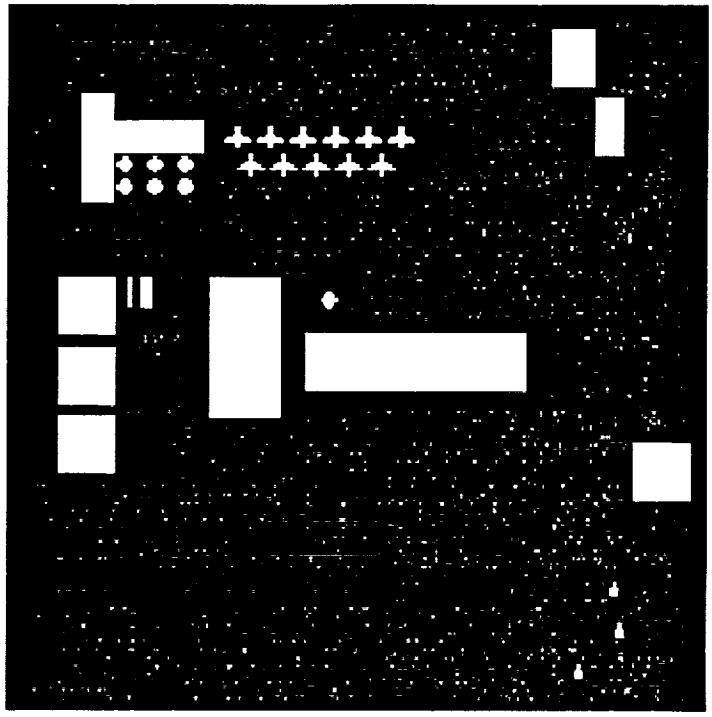


Image 4

As we can see in comparison to the 10 different noise images, the new image seems to be cleaner for both the buildings and surroundings.

CONCLUSION

Although we were not able to process the images efficiently in MPI we did some improvements in serial machines, as can be seen above.

Although, there seems to be no single method that comes out the best or outstanding to clean the images but as can be seen and judged that it fairly depends upon the user and the application that we are trying to apply when we are cleaning the images. The method to find the mean of the noise elements centered around the median of the order statistics seems to be the best in terms of removing noise for both objects and surrounding areas.

ACKNOWLEDGEMENT

The author gratefully acknowledge Hewlett Packard for providing some laboratory facilities for the communication and image processing laboratory.

REFERENCES

1) ASF SAR Facility website: www.asf.alaska.edu .
2) Schaum's outlines: Programming with C, second edition, by Byron Gottfried.
3) Matlab reference manuals, version 5.
4) Parallel Programming with MPI, by Peter S. Pacheo

APPENDIX I

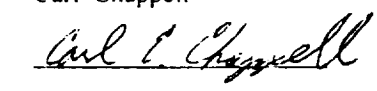
A list of African-American students who benefited from this grant:

Jill Barfield	Tution Fees
Latangya Benson	Tution Fees
Perry Alexander	Tution Fees
Rico Ashley	Research Assistant
Jill Barfield	Research Assistant
Allen Lykes	Research Assistant
Jermal Babb	Research Assistant
Perry Alexander	Research Assistant
Carl Chappell	Research Assistant
Arkea Robinson	Research Assistant
Channing Corley	Research Assistant
Larry Stevenson	Research Assistant

Progress Report

On Spring Semester 2000 I, Carl Chappell, received a tuition grant from Dr. Chandrakanth H. Gowda of Electrical Engineering Dept. at Tuskegee University. During this class period while securing the final credits for my Bachelors degree I agreed to be contracted by the Aerospace Engineering Department for undergraduate research in the Aerospace Dept. For this job I would be acting as computer lab administrator. My responsibilities included rebuilding existing software structures for Unix workstations and Windows based PC's, configuration of the lab to the University Network, assessments of potential hardware upgrades, and setting up a network printer server.

Carl Chappell



Subject: NASA Grant Report
Date: Fri, 14 Jul 2000 15:07:07 -0500
From: Chandrakanth Gowda <chandra@tusk.edu>
Organization: Tuskegee University
To: seif@ceet.niu.edu, j.bhuyan@computer.org

Dr. Seif,
I am in the process of writing a report for the NASA Grant# NAG1-1865. Since you were the Principal Investigator during the first three years of this
grant, I would appreciate if you could provide some sort of documentation
on how your part of the grant money was spent and all the achievements that were accomplished. This will greatly help in the completion of the report.

Regards
Chandra

Dr. Chandrakanth H. Gowda
Assistant Professor
Department of Electrical Engineering
Tuskegee University