2019 version

Faculty Member: James T Adams **Faculty ID:** 20292674

Department: Physics, Engineering, Astronomy **Faculty Email:** adamsjt4@sfasu.edu

Have you previously received a SURE award? Yes **If yes, when?** Summer 2018

If yes, how did you disseminate results from previous awards (successfully published a paper or obtained a grant, submitted paper or grant based on results, presented results at external conference, etc.):

Results were given in a SURE presentation at the end of the summer and displayed in a poster in the STEM building.

Student's Name: Dakota Jones **Student ID:** 20236453

Major: Computer Science **Student Email:** jonesdl17@jacks.sfasu.edu

Have you previously received a SURE award? No **If yes, when?**

Proposed SURE Project

Title of proposed SURE project: Polarimetric Data Toolkit and Analyzer

Description of proposed project (describe the scope of the project, including specific objectives):

Reflected light from different materials shows distinct linear degrees of polarization as a function of source and observer positions. Because of this fact, it is possible to distinguish between known materials by making polarimetric observations. In order to be useful for a wide range of materials and applications there needs to be software for managing the data from known materials and a way of processing and comparing new or unknown materials to the database. This SURE project will develop an application for processing this data.

The specific objectives will consist of the following.
1. Create a MySQL database for storing polarimetric data including metadata for sample material type, collection dates, and polarimeter settings including focal length, shutter speed, and ISO values.
2. Create a web application for viewing existing polarimetry data in the database and adding new collected data.
3. Add a service to the web application for comparing and matching polarimetric data to those in the database.
4. Use the data from the previous SURE project which includes polarimetric data for black sand, black salt, white sand, white salt, and four other materials to test and verify the data add capability of the application.
5. Collect and input data from polarimetric observations of black sand and white sand in order to test the data matching capability of the application.

Is this a new project or a continuation of a current project? If a continuation, what new work will be done as part of SURE?

This is a continuation of a project from last summer and a SURE project. The previous work developed a method for collecting data from a simple polarimetric setup using a commercial camera. This SURE project will develop the application that stores, views, and compares polarimetric data and provide a proof of concept for using this device to categorize and identify materials.

Potential impact or significance of research:

Polarimetry for remote sensing is currently an expensive undertaking requiring complex custom equipment. If this simple technique using a commercial camera and polarizers is successful, it could provide a practical and inexpensive method for applying polarimetry to the remote identification of materials. This method could be applied to mineral exploration and geology as well as to remote sensing of astronomical objects.

The impact of this research would be a demonstration of this method of polarimetry to the categorization and identification of materials. While earlier research showed that unique polarimetric signatures exist for materials, this SURE project would should how these signatures could actually be used in the field as well as showing the strengths and weaknesses of this method.

Research Design (approach/methodology):

Our approach will use an Agile inspired methodology. Specifically we will use a lean design philosophy to produce an application that has specific functions and capabilities, and will minimize developing any extra or unnecessary code. In Agile development incremental changes are implemented in short periods of time (on the order of 1 or 2 days) rather than planning weeks or months of development work between deliverable changes.

This application will ingest data, display data, allow simple search of data, and comparison of data, and nothing else. By focusing on making the application lightweight in terms of capability it will make it possible to develop a useful application in the short development time available in a single summer semester.

Literature review for project (must provide at least five peer-reviewed sources):

These articles are grouped by supporting type. The first describes the simple polarimeter we use for data generation, the second and third show the results of observing the polarization of light reflected from surfaces. The last two show more applied research into identifying materials and discriminating between them based on polarization observations.

1. **"Observation of non-principal plane neutral points in the upwelling polarized light field above a water surface",** James T. Adams, Deric J. Gray, and Simon Rayner, Applied Optics 51(22), 5387-5391 (2012).

2. Hsi-Shu Chen and C. R. Nagaraja Rao, "**Polarization of light on reflection by some natural surfaces**," Brit. J. Appl. Phys. (J. Phys. D), Ser. 2, Vol. 1, 1191-1200 (1968).

3. "**Polarization of light reflected from rough planetary surface**", M. Wolff, Appl. Opt. 14, 1395-1405 (1975).

4. "**Active Polarimetric Measurements for Identification and Characterization of Space Debris**", M. Pasqual, K. Cahoy, IEEE Transactions on Aerospace and Electronic Systems, Vol. 53, Issue 6, Dec. 2017.

5. "**Object separation by polarimetric and spectral imagery fusion**", Y. Zhao, L. Zhang, D. Zhang, Q. Pan, Computer Vision and Understanding 113 (2009) 855-866.

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Project timeline (activity/task and time to complete):

Week 1 – Design database schema in MySQL for storing polarimetric data and write Java classes and connectors for representing, writing, and reading this data.
Week 2 – Design and implement the front end for listing data in the database and displaying the simple polarimetric curves selected. This will involve HTML and JavaScript development and interfacing with the previous objects representing the data.
Week 3 – Write a simple comparison class for matching polarimetric curves. Part of this task will require choosing the algorithm for comparing two curves. Most likely this will be a simple point distance comparison between two curves.
Week 4 – Complete testing of our application and finish the poster and presentation for completion of the project.

Description of research and professional skills that the student will develop from the project:

The student researcher will develop several marketable skills on this project including the following:
1. Design and integration of a database with software.
2. Design and implementation of a web application front-end that actually ingests, manages, and displays scientific data. This is a valuable professional skill to have, especially since it will demonstrate a knowledge of basic data management development.
3. Developing software on a team. This project will not be hugely complex, but it will have a division of work between the student and faculty requiring sharing and modification of a common code base. This will rely on using the GIT software versioning control system, a lightweight but commonly used tool.

Description of the involvement and activities that the student and mentoring faculty will have in this project:

Dr. Adams will write a description of the polarimetric data and design the initial database schema. He will then write a UML (Universal Modeling Language) design of the application at a high level. The student will sketch out a design for the application interface and display.

After this initial design work, the student and Dr. Adams will work together to implement the MySQL database, the front-end in HTML and JavaScript, and the intermediate software needed for data processing and to tie the interface to the database.

The student and faculty efforts will consist almost entirely of software engineering activities and can be done on existing university and lab computers. Reference polarimetry data already exists for the design portion of this project and additional test data will be collected in Dr. Adams's lab using the simple polarimeter and method shown in the earlier SURE project.

Description of how you will disseminate results from the project:

The results of this project will displayed and shown in the final SURE presentation and will also be combined with the previous SURE projects results for a submission to a refereed journal such as Applied Optics. The use of inexpensive commercial cameras combined with a lightweight software application capable of demonstrating the utility of the data collected makes this work suitable for publication.

Budget ($0-$500 with justification):

The following items will be purchased for this project.

1. Lab Notebooks and pens for design work.
2. Polarizing and tinted filters for final sample data collection.

Amount requested for supplies from SURE: ~~$200.00~~ $500.00

Amount requested for supplies from department: $500.00

Amount department will fund faculty stipend: $500.00

Amount department will fund student stipend: $_____

Chair approval: Joe Mumm

Chair Signature

For H.D.

I have reviewed and agree to fulfill the expectations of the SURE award.

Dakota Jones

Student Signature

Faculty Signature

For internal purposes only:

Proposal Awarded _____ Proposal not award_____ Amount awarded: _____

Accounts to be used for award:_____