Project Title: **ENRTF ID:**   032-A

Automated Boulevard Tree Inventory and Urban Forest Management

Category: A. Foundational Natural Resource Data and Information

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Total Project Budget: $ 154,656

Proposed Project Time Period for the Funding Requested: 3 years, July 2018 to June 2021

Summary:

Build an automated boulevard tree inventory and assessment system which rapidly and inexpensively gathers community tree data, helps manage and develop urban forestry resources, enhances community well-being, and supports education.

Name: Ramnath   Sarnath

Sponsoring Organization: St. Cloud State University

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            St. Cloud   Minn   56301

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Web Address

Location

Region: Central

County Name: Benton, Sherburne, Stearns

City / Township: Sartell

Alternate Text for Visual:

Data in the form of imagery, video and GPS is captured by vehicle mounted automated cameras, or civilian/student volunteers. The visual analysis system will identify tree species, size, location, and other relevant statistics. Once stored in a database this information could serve to assist land management decisions, or other research and educational efforts. These activities will lead to enhanced urban forests and greater community well-being.

_____ Funding Priorities	_____ Multiple Benefits	_____ Outcomes	_____ Knowledge Base
_____ Extent of Impact	_____ Innovation	_____ Scientific/Tech Basis	_____ Urgency
_____ Capacity Readiness	_____ Leverage	_____ TOTAL	_____%

PROJECT TITLE: Automated Boulevard Tree Inventory and Urban Forest Management

I PROJECT STATEMENT

This project will build an automated boulevard tree inventory and assessment system for communities across Minnesota, that often lack the resources needed to proactively manage this resource. A vehicle-mounted camera will capture tree images with location information, which will be automatically uploaded to a database. Virtual inspections, automated to the maximum possible extent, will augment the collected data. Statistical analysis tools will provide decision-support and monitoring ability to city officials. The system will also function as an educational support tool for students and citizens.

The Current Situation. Developing and maintaining a tree inventory can be a labor-intensive task. Currently, most Minnesota communities can only react to problems as they arise: dead trees, storm damage, blocked signage, heaving sidewalks, etc. They are unable to invest resources needed to conduct an inventory or plan on how they can improve their urban forests. Some communities have engaged citizen volunteers, but data collection is limited and often not accurate or easily accessible. At present, it is difficult to formulate strategies for dealing with invasive pests and diseases such as Emerald Ash Borer, Dutch elm disease and Oak Wilt, or to identify opportunities for increasing tree cover.

Technology Needed. The visual data collection technology is similar to *Google Street-view*, with some adaptations. However, *Google Street-view* does not provide up-to-date tree information and the quality of the images is not adequate for virtual inspections, statistical analysis or automation. Open source tree databases, like *iTree,* will be suitably enhanced to serve as the platform for storing data.

Challenges We Face. The data should be precise enough to enable city officials to identify the location and species, evaluate tree health and exploit the potential for tree planting. The database will need periodic updates, and additional information from virtual inspections will need to be integrated. Secure access from various locations will be needed, for community use and for educational purposes. The system must meet requirements of accuracy, accessibility, cost, efficiency and versatility.

Expected Benefits. Urban forests provide multiple benefits: they improve our air quality, mitigate for storm water, provide wildlife and pollinator habitat, and promote energy conservation and community health. This system will enable cities to enhance the urban forest cover by aiding new tree preservation and supporting ordinances aimed at increasing and preserving the urban forest canopy. It will provide Environmental Science classes with hands-on activities and help train citizen volunteers on tree management. The information will allow other state agencies to model environmental scenarios that are influenced by urban forests. For example, tree canopy cover influences how quickly storm water reaches lakes and rivers. The system can be adapted to most urban settings with few changes.

II PROJECT ACTIVITIES AND OUTCOMES

Activity 1: Develop and test automated visual data collection system   **Budget: $58,000**
In this phase, we will set up a vehicle-mounted camera system to collect and automatically upload necessary data. The images should provide sufficient detail so that species of trees can be identified, and parameters like trunk width, quality of foliage, etc. can be efficiently deduced. The system will be fine-tuned and validated to ensure that image quality is adequate for virtual inspections. Initial tests of the system will be carried out in a familiar environment, i.e., locations where data is already available.

Outcome	Completion Date
1. Identifying appropriate technology	July 31, 2018
2. Acquiring necessary hardware and deploying it	October 31, 2018
3. Testing and fine-tuning the system for data collection	March 1, 2019

Activity 2: Assessing the system and modifying for intended use   **Budget: $54,500**
This phase involves working with a select group of citizen volunteers, and training them to perform

virtual inspections and augmenting the information in the database. This training will be imparted through the Stearns County Soil and Water Conservation District. Data will also be collected from unfamiliar environments (e.g. locations where no prior information is available), and used to answer queries for maintenance. Effectiveness of data updates and virtual inspections will be evaluated. Accuracy of the input of citizen volunteers will be monitored on various datasets.

Outcome	Completion Date
1. Setting up a database server for remote access	May 1, 2019
2. Collection of data from unfamiliar environment	September 30, 2019
3. Engaging citizen volunteers and assessing effectiveness of participation	October 31, 2019

Activity 3: Deploy system and use as an educational tool   **Budget: $42,156**

The system will be used in the City of Sartell to collect data and the database queries and statistical analysis will be used to aid in decision making. Various options will be explored, including mounting the cameras on garbage trucks, with a plan to develop a system that can efficiently provide update information. Staff in the city office will be trained to access the system and will monitor system effectiveness. Environmental Science students at Sartell High School and Saint Cloud Technical High School will use the system as a learning tool. Results will be presented at statewide conferences.

Outcome	Completion Date
1. Carrying out data collection using garbage trucks and other vehicles	July 31, 2020
2. Gauging effectiveness of deployment in the City of Sartell	December 31, 2020
3. Using the system as an educational tool and evaluate results	June 30, 2021

III PROJECT STRATEGY

A.   Project Team/Partners

Project Partners Receiving Funds:

- Dr. Ramnath Sarnath, Professor, Department of Computer Science and Information Technology, Saint Cloud State University [$26,000]: Management of the project; assist with software design.
- Dr. Omar Al-azzam Assistant Professor, Department of Computer Science and Information Technology, Saint Cloud State University [$25,000]: Database and software development.
- Mr. Wayne Cymbaluk, Water Resource Specialist, Stearns County Soil & Water Conservation District [$5,000]: Provide expert advice on techniques used for tree surveys, and relevant technologies. Consult with team on community needs and best practices.
- Mr. Mark Gill, Visualization engineer [$15,000]: Provide expertise in identifying, acquiring and deploying appropriate technology, and setting up and maintaining the server for receiving data.

Project Partners Not Receiving Funds:

- Ms. Angela Haus, Environmental Science teacher, St. Cloud Technical High School and Mr. Ben Hoffman, Environmental Science teacher, Sartell High School: Use tool as an educational resource.
- Mr. Nate Keller: Advice on conditions in Sartell such as right-of-way width, street features; coordination between the project team and the City's Public Works, Engineering/GIS departments.

B.   Project Impact and Long-Term Strategy

The system will be promoted across the state at venues like the conferences for Minnesota City Managers Association and Minnesota Association of Soil and Water Conservation Districts. In the proposed system, the level of automation will be limited; in the long-term, we will enhance this feature. For example, intelligent image processing techniques can automatically characterize tree health.

C. **Timeline Requirements**

The project will start in July 2018 and continue for 3 years to allow time for developing and deploying the system, data collection and processing, deployment and validation.

2018 Detailed Project Budget

Project Title: *Smart Boulevard-Tree Inventory System for Minnesota Communities*

IV. TOTAL ENRTF REQUEST BUDGET 3 years *(36 months)*

BUDGET ITEM	AMOUNT
Personnel:	$ -
Dr. Ramnath Sarnath: Project manager; 13 days in year 1 and 2 (equivalent to 9% FTE per year in 9-month contract); 7 days in year 3 (equivalent to 5% FTE in 9-month contract); daily rate $652.71 plus fringe in year 1 with 4% increase for Year 2 & 3; total includes approx. 83% salary and 17% fringe	$ 26,702
Dr. Omar Al-azzam: Data analysis, database development and software development; 14 days per year (equivalent to 11% FTE per year in 9-month contract); 7 days in year 3 (equivalent to 6% FTE in 9-month contract) daily rate $515.08 plus fringe in year 1 with 4% increase for Year 2 & 3; total includes approx. 73% salary and 27% fringe	$ 25,496
Mr. Mark Gill: Develop Visualization platform using Geographical Information System, incorporate remote sensing technology, and provide technology support; 12 days per year (equivalent to 6% FTE in 12 month contract) for each of the three years; total includes approx. 70% salary and 30% fringe	$ 15,226
Wayne Cymbaluk Water Resource Specialist Stearns County Soil & Water Conservation District, 64.5 Hrs at $77.39 Hr	$ 4,992
Undergraduate Student Employees: 2 students at 20 hours/week for the equivalent of 5 semesters (70 weeks total), $12/hour	$ 33,600
Professional/Technical/Service Contracts:	$ -
Equipment/Tools/Supplies:	$ -
GPS-enabled Camera and Mount System for data collection; 3 sets at $5,000 each	$ 15,000
Explore various options for deploying system on vehicles used for other purposes	$ 15,000
Server to house the database	$ 5,000
Hardware and software systems maintenance, repair, and upkeep	$ 3,000
Printing/paperwork/office supplies	$ 1,000
Travel:	$ -
Field trips for high school students	$ 1,000
Mileage - travel to and from data collection sites; $0.47/mile, 12,000 miles	$ 5,640
Attend conferences on city administration and soil and water conservation to explain the system; $500 each, 2 meetings per year (6 total)	$ 3,000
TOTAL ENVIRONMENT AND NATURAL RESOURCES TRUST FUND $ REQUEST =	$ 154,656

V. OTHER FUNDS *(This entire section must be filled out. Do not delete rows. Indicate "N/A" if row is not applicable.)*

| SOURCE OF FUNDS	AMOUNT	Status
Other Non-State $ To Be Applied To Project During Project Period: *N/A*	$ -	
Other State $ To Be Applied To Project During Project Period: *N/A*	$ -	
In-kind Services To Be Applied To Project During Project Period:	$ -	
Because the project is overhead-free, laboratory space, electricity, and other overhead costs are provided in kind. The SCSU indirect rate is 12%	$ 18,559	Secured
Organizational help and coordination with school districts provided by the IGNITE center	$ 1,500	Secured
Consultation services provided by Mr. Nate Keller, City of Sartell	$ 2,000	Secured
Funding History: *N/A*	$ -	
Remaining $ From Current ENRTF Appropriation: *N/A*	$ -	
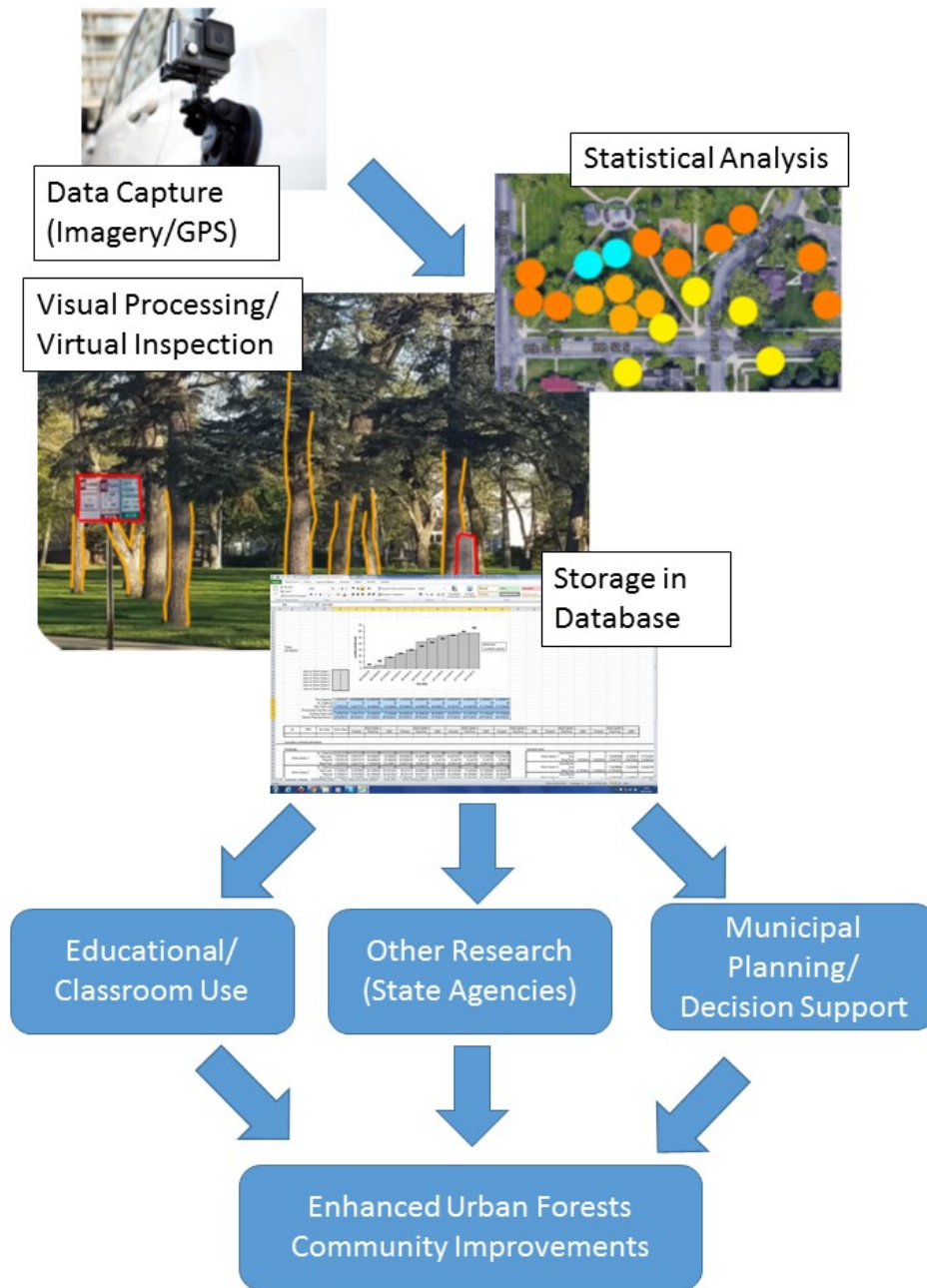
Figure 1: Data in the form of imagery, video and GPS is captured by vehicle mounted automated cameras, or civilian/student volunteers. The visual analysis system will identify tree species, size, location, and other relevant statistics. Once stored in a database this information could serve to assist land management decisions, or other research and educational *efforts. These activities will lead to enhanced urban forests and greater community well-being.*

Project Manager Qualifications & Organization Description:

The project team will be led by Professor Ramnath Sarnath. He holds a B.Tech degree in Civil Engineering and an M.Tech degree in Computer Science from the Indian Institute of Technology, New Delhi. He has a Ph.D. degree in Computer Science from the State University of New York at Buffalo. He has extensive administrative experience, expertise in software design and has worked with algorithm development for large data sets.

Dr. Omar Al-Azzam is an assistant professor at St. Cloud State University. He obtained his PhD from North Dakota state university, Fargo, ND. Dr. Al-Azzam has worked in several predictive modeling research project, such as, predicting gene ontology from protein domains, predicting gene location and constructing consensus genome maps. Dr. Al-Azzam main research interests include: software development, database applications, data mining, bioinformatics, big-data analytics and modeling.

Wayne Cymbaluk works as a Water Resources Specialist with the Stearns County Soil and Water Conservation District. He provides natural resource management and protection expertise to resource users within Stearns County. He holds a M.S. in Natural Resource Management from North Dakota State University.

Mark Gill is the director of the SCSU Visualization Lab. He holds an M.S. in Software engineering and has 20 years of experience in the realm of 3D visualization, Virtual Reality, and high-performance data presentation. Over the course of his career, Mark has developed, or overseen the development of several 'big data' or time-sequenced visualization projects, which would fall in line with the goals and deliverables of this proposal. He also has experience with use of GIS.

Nate Keller is the Community Development Technician for the City of Sartell where he specializes in Planning, Zoning, and Sustainability efforts for the City. He holds a B.A. in Community Development and Planning from St. Cloud State University. Nate leads the City of Sartell's *Greenstep* program where he has worked on numerous initiatives involving sustainability, the environment, and storm water.

Ben Hoffman is a Science teacher at Sartell High School. He has a BS Degree in Life Science from Bemidji State University and a MA in Teaching and Learning from St. Mary's University. He has taught various science courses in Sartell over the past 12 years including Biology, Minnesota Wildlife, and Principles of Engineering. Ben is currently developing Environmental Science Curriculum for a new course to be offered next year.

SCSU has undergraduate programs in Computer Science and Software Engineering, and an MS program in Computer Science. The Integrated Science and Engineering Laboratory Facility (ISELF) building provides the facilities needed for this project. A high speed data link is available to campus, so that the server housing the proposed system can be easily accessed by all agencies.