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KEYWORDS: Big data, decision making, social science theories, computer analytics, interactive display techniques, temporal data streams

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OSD13-LD3 TITLE: Layered Data to Areas of Interest

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: The objective of this research is to use spatial, temporal and graph analysis techniques to take very large data streams over wide areas and autonomously highlight areas of interest for a decision maker without a priori knowledge of the area and/or location of high value.

DESCRIPTION: To protect U.S. national interests and achieve the objectives of the 2010 National Security Strategy, the Joint Force will need to recalibrate its capabilities and make selective additional investments [1]. The well-publicized push to the Pacific Rim drives a need to improved mission planning over much larger areas, including some for which conventional information gathering is challenging. Improved pattern recognition capabilities enabled by spatial, temporal and graphical analysis are one way to effectively improve mission planning and execution given limited resourced.

The U.S. Marine Corp desires to improve battlespace awareness (to know the enemy and environment) through improved analysis, prediction and production [2]. Relevant raw data can usually be stored and subsequently visualized spatially, temporally or as a graph. The automated recognition of an area and/or location of high value is basically a pattern recognition problem that must be solved in the absence of a data that is naturally tied to a uniform grid. Data about remote areas can still include imagery, radar and open source which can include social and cultural information. The diversity of this data set makes the establishment of the uniform grid often required by pattern recognition algorithms challenging [3]. The extraction and preprocessing of features from raw data is also challenging due to the well-known influences of environmental, social and cultural influences on the importance of other observed features [4]. Cognitive processes and context need to be considered by location/area of interest pattern recognition algorithms. [5]

The technical challenges of this topic are as follows: 1) Select and automate the population of a feature layer; 2) Preprocess data as required to approximate a uniform grid; 3) uncover linear/ nonlinear correlations between environmental, social and cultural variables and feature importance; 4) Mature models for why/when a location/area would be of interest; 5) Mature pattern recognition algorithms that approximate human recognition and classification skills utilizing cognitive insight; 5) provide a means to visualize current and predicted states (e.g. heat maps showing locations/areas of interest given a context). Define and apply metrics to measure modeling and prediction accuracy and potential for success of products produced.

Creative solutions are desired. Data used should be relevant to potential use for product transition, such as a government agency, program of record or commercial market place. Use of open standards is encouraged to reduce costs and improve system interoperability.

PHASE I: Identify a geographic region for study and data layer design concept. Demonstrate that diverse types of data can be ported to a spatial grid structure relevant to pattern recognition. Develop features models for areas of interest and then perform a proof of concept demonstration of a pattern recognition capability. The demonstration should be conducted using open source data. Document results from analysis and tests in a technical report or paper at a selected conference. The final Phase I brief should show plans for Phase I Option 1 and Phase II.

PHASE II: Produce a prototype system that is capable of rapidly identifying locations/areas of interest based on a given context and visualizing that information as spatial heat maps with data traceability. The system should be able to automatically process data as sequential batch files or streaming data, accepting all standard raw data formats for images, maps, tracks, text and graphs. It is desired that context and pedigree of information be maintained for operator review. At this point the performer should focus on a proof-of-concept of capability of interest to transition program.

PHASE III: Produce a system capable of deployment and operational evaluation. The system should consume available operational data sets and focus on areas that are of interest to specific transition programs or commercial applications. Machine based processing steps and metadata should be accessible by operator and presented in human understandable form. The software and hardware should be modified to operate in accordance with guidelines provided by transition sponsor.

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KEYWORDS: Pattern recognition, spatial grid analysis, activity detection, data features, prediction, cognitive science

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OSD13-PR1 TITLE: Direct Injection Systems for Improved Performance, Durability, and Economy

TECHNOLOGY AREAS: Air Platform

OBJECTIVE: Develop and demonstrate an advanced high pressure, heavy fuel (JP-8) injection system for UAS/UGS applications, capable of performing multiple injections per cycle.

DESCRIPTION: This effort is to develop a fast responding, light weight, direct injection system to operate within the fuel's ignition delay time for UAS/UGS application. These systems must be applicable to engines that are 200 HP or less, either reciprocating or rotary. A technical challenge associated with the conversion of gasoline engines to heavy fuel (JP-8) is the avoidance of knock. An approach used to avoid knock is to operate within the fuel's ignition delay time; hence to employ direct combustion chamber injection.

The challenges of the reciprocating engine are to avoid end gas knock (auto ignition occurring in the end gas after spark) and to inject the fuel very late into the cycle. The challenges for the rotary engine are atomization and the avoidance of wall quenching due to its combustion chamber shape. Delaying the injection process causes higher pressure rise rates which can exceed the engine's design capabilities. An injection system that offers fast response and multiple injections per cycle may alleviate excessive pressure rise and the avoidance of knock.

Good combustion control eliminates many durability issues from overloading, shock, and combustion deposits. The shape of the combustion trace can be tailored through multiple injection pulses and combustion deposits can be controlled with better atomization and fuel patterns. Hence an injection system that offers fine atomization, fast response, and multiple injections per cycle is needed. System components are to include injectors, high pressure supply pump (1000 bar min), feed pump and controller with harness.

PHASE I: Develop an improved fuel injector capable of performing multiple injections per cycle, operating at high pressures (above 1000 bar) and producing droplet sizes finer than 10 to 15 microns. These injectors will result in improvements to the direct injection process for reciprocating and rotary UAS engines. Analytical predictions of spray pattern through Computational Fluid Dynamics (CFD) and 3-D computations are desired. Bench tests of fuel system components operating at designed pressures and quantification of injection spray pattern are desired. The fuel injection system should have the capability to perform multiple injections per cycle and at engine operating speeds up to 6,000 rpm.

PHASE II: Demonstrate and validate the performance of the Phase I technology in a laboratory environment on a representative engine. Engines should be of size and power appropriate for the Predator and Shadow-200 UAV class. Further analytical modeling and spray tests must supplement engine testing. The avoidance of knock while operating on JP-8 and delivering equivalent power is the desired outcome.

PHASE III DUAL USE APPLICATIONS:
Military Application: This technology is applicable to Air Force, Navy, and Army small, heavy fuel engines currently under development. The conversion and design of heavy fuel engines necessitates high responding injectors capable of fine atomization, fast response, and multiple injections per cycle. These injectors have the potential to be incorporated into engines such as the USAF's Predator-Rotax 914 and the US Army's Shadow-200 to minimize damaging effects of knock and to avoid wall quenching through fine atomization.
Commercial Application: This technology has additional transition opportunities in the commercial sector for ground vehicles or civil UAVs. Companies could incorporate the injectors, high pressure supply pump, feed pump and controller with harness to optimize the fuel injection associated with the engines. This could lead to cleaner combustion that could greatly increase the life of the engine. Further, advanced direct injections systems have the potential to reduce specific fuel consumption.

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