Gun Control Network—A System Theoretic Development

A Proposal Submitted to:
The National Science Foundation (NSF)
Small Business Innovation Research (SBIR) Program
FY-2014 Phase I Solicitation Release 2 (13-599)
TOPIC: Information and Communication Technologies

PROPOSAL P.I.: Noah B. Jacobsen, Ph.D.
PROPOSING FIRM: Aquerre Technologies LLC

Part 1. Identification and Significance of the Innovation

In 2012, firearms were used in 69.3 percent of the nation's murders, 41.0 percent of robberies, and 21.8 percent of aggravated assaults—corresponding to a total number of 321,469 violent crimes involving firearms [1]. Seven of the twelve deadliest U.S. shootings since 1949 occurred at a school, university or government building [2]. The research innovation proposed in this SBIR application is the development of gun control technology based on state of the art predictive information systems science. A key target application of the proposed technology is anticipatory threat interjection and emergency response.

Our proposal is submitted to the Information and Communication Technologies Topic of the NSF 13-599 Solicitation (Sub-topic: Information Technology Applications). The 2013 Kinsey report referenced in the topic description [3] supports the claim that predictive information systems like the one developed in this proposal will deliver a large and disruptive economic impact across the technology markets within the near future (by 2025). Moreover, successful development and commercialization of new gun control technologies represents the potential for a major step forward towards addressing the significant societal issue of gun violence in the United States.

Today, predictive information science is widely applied across technology markets, including financial, automotive, and communication technologies. For example, Bayesian predictive methods are applied in physical-layer radio-communication engineering applications in [4]. We claim that existing predictive systems are complex and expensive, and unpractical for large-scale commercial deployment for the application of gun control. As the state of the art of predictive information science yields more practical and effective systems, the application of gun control in the United States represents an important emerging market opportunity. In this NSF SBIR proposal, Aquerre Technologies seeks to lead the development of a revolutionary scalable, practical and effective gun control technology solution.

The proposed technology uses graph-based statistical inference processing, communication and control algorithms. Our design leverages proprietary expertise and original research performed by the staff of Aquerre Technologies as well as the system engineering R&D community. The results of the Phase I study will be used to substantiate patent applications for the technology. Our system features model discovery and predictive information processing methods using a factor-graph development framework. Specifically, we use factor-graphs to model system dynamics and message-passing algorithms to estimate unobserved system variables. Our design approach emphasizes scalability to large systems (large number of variables) using sparse graphs to represent/approximate system dynamics. We plan to demonstrate that the use of sparse representations yields computationally efficient algorithms that scale practically to large systems.

This proposal includes a radio-sensor testbed component to complement the Phase I algorithm development activities. The "Phase I Testbed" is planned to be a relatively simple development system, consisting of a couple of radio-sensor terminals (laptops) and a radio-UI terminal. At the completion of the six month Phase I segment, the Phase I testbed will be able to demonstrate a basic application of the predictive algorithms, such as cooperative predictive tracking. The planned Phase II segment of this proposal includes a large-scale testbed (Phase II Testbed) which will be used to test our methods in a big-data environment. We will further emphasize the development of a viable commercial solution, using a network of simple, low-cost radio-camera sensors. Finally, we include a UI/data rendering software component based on open source code packages. We plan to develop a basic 3-dimensional virtual environment for rendering and manipulating sensor output data, user visualization and program interaction.

Feature highlights of our technology:

(A) Cooperative data procesing—In addition to individual sensor measurements/reports, the proposed network utilizes *cooperative* signal processing, communication and control methods to facilitate advanced tracking and threat detection performance. The Phase I testbed will be used to demonstrate an example of performance enhancement with cooperative processing methods. For example, two cameras tracking the same object might exchange information to effectively enhance the resolution of each individual camera. Similarly, a polling strategy could be evaluated for cooperative detection of a breach in threshold event, etc. Our firm has research and development expertise on the subject of cooperative communications methods for wireless systems [5].

(B) Multi-input, multi-output data processing—In addition to direct surveillance data inputs, our advanced system will use networked data/information-service inputs via an Application Programming Interface (API)-like framework. Our commercial system will be able to accommodate a rich set of data input sources and provide multi-structure/multi-application data outputs.

(C) Scalability to large systems—Scalability is a primary design consideration of our proposed development track. We argue that an ideal predictor may only benefit from the inclusion of additional data inputs and that an advanced system may be required to adapt itself due to dynamic environment and/or program objectives, all of which leads to uncertainty in model description and information relevance. These factors require the development of methods that can handle big-data input sources and a large number of variables. In Phase I, we seek to develop reduced-complexity implementations that can scale to big data sets and complex large-scale systems, and in Phase II we propose to evaluate our methods against a large-scale test system.

(D) Adaptive system models—Our advanced technology will re-reconfigurable depending on the application of use. The example embodiment of the methods developed in Phase I of this program is a wireless sensor network security technology. We develop a technology that will dynamically configure its communication and control processing algorithms based on dynamically varying situational environments in order to provide the best possible output data at any given instant.

Gun Control Applications and Beyond: The predictive information system developed in this SBIR proposal has far reaching applications, beyond gun control, including applications of interest to the U.S. government and private sector customers. We anticipate that the basic methods developed in this proposal will be capable of addressing multiple market opportunities, resulting in a greater chance of commercialization success.

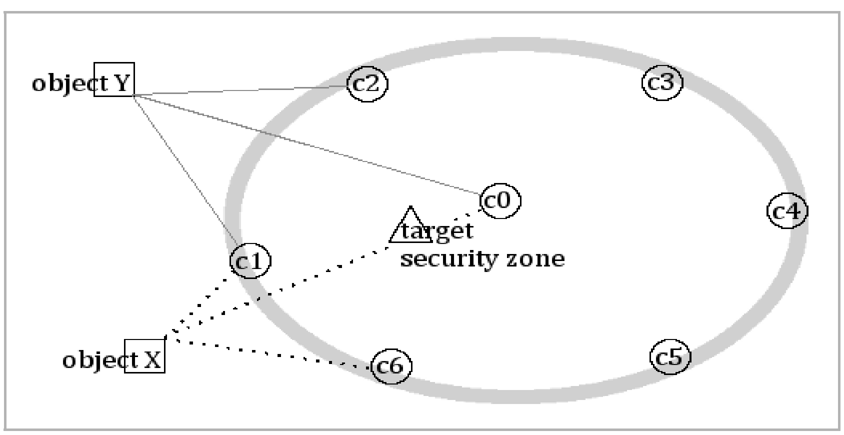

Fig. 1. A “Gun Control Network” tracking two objects.

Part 2. Background and Phase I Technical Objectives

Figure 1 depicts an illustration of the product concept developed in this SBIR application. Our proposed “Gun Control Network” technology is comprised of (i) a network of sensor-radio terminals and user-interface (UI) terminals, (ii) a collection of predictive information signal processing, communication and control algorithms, (iii) a user visualization/interaction software interface, and (iv) an interface for data inputs and outputs. We envision a use-case in which the security network in Fig. 1 is searching for and tracking guns (or, more generally, weapons) in the vicinity of a protected property/asset. In addition to local sensor-reports, our advanced system will interface with a plurality of source data inputs, such as internet based data and information services, augmenting the predictive-processing functionality of our technology. For example, suppose the camera-sensor network in Fig. 1 identifies a human subject within its field, the system might obtain further information by matching images with a networked database. Our “internet of things” gun control technology concept will utilize a plurality of networked multi-structure, multi-source data inputs to enhance user feedback data whenever possible.

2.1. Summary of the Innovation Context

2.1.1. An Internet of Things Concept

The Internet of Things--networks of low-cost sensors and actuators for data collection, monitoring, decision making, and process optimization --has the potential to create economic impact of $2.7 trillion to $6.2 trillion annually by 2025 [3]. Our innovation leverages networked wireless and wired internet devices to provide improved predictive gun control feedback data to the user by collaboratively processing sensor-based data and network information service based data. Our *ad hoc* concept includes an API-like exchange for data inputs and data outputs coupled with dynamic adaption of the communication, control and signal processing algorithms based on network/program realization. We further plan to support dynamic application objectives—beyond predictive gun control applications—with future product embodiments.

2.1.2. Big-Data and the Ideal Predictor

By making the best use of observed data, an ideal predictor inherently disregards statistically irrelevant information. Thus, an ideal predictive system may only benefit from the inclusion of additional data input sources. Given an ample supply of big-data, the challenge of predictive information systems engineering lies in extracting the most statistically relevant information and finding tractable algorithms for the program application. In this proposal, we investigate metrics for determining statistical relevance between data sets. Namely we investigate a “Quality of Relation” (QoR) metric based on low-order statistical moments for determining statistical relevance and estimating the system model given a supply of data. Our research plan is to use random-sampling methods to mine for statistically relevant data using the proposed metric.

2.1.3. Model Uncertainty and Graph Discovery

In this proposal, we leverage our expertise in analysis, design, and construction of high-performance error-control codes to develop proprietary graph-based predictive information processing methods for the application of gun control. In the error-control coding problem, the code may be viewed as a kind of graph that is designed by the engineer to achieve the desired performance characteristic. In the gun control problem, at least part of the underlying graphical model must be learned by the inference processing engine. We address the aspect of model uncertainty with the development of "Graph Discovery" methods for adaptive graph learning, uncovering statistical relationships, and finding low-complexity representations. When part of the system model is *a priori* unknown, our proposed "graph discovery" methods will (i) directly estimate the graphical model based on observed data and user input and/or (ii) estimate the variables of interest by statistically sampling an ensemble of sparse factor-graph approximations —thereby yielding predictive estimates in spite of uncertainty in system model description.

2.1.4. Scalability to Large Systems

Our plan further includes the study of sparse graph representations of system dynamics to obtain computationally efficient algorithms. In this proposal, we utilize a factor-graph based inference processing framework for the application of predictive gun control. Our design approach emphasizes scalability to large systems: We propose "Graph Discovery" methods that attempt to find low-complexity representations based on sparse graph models, and we utilize efficient factor-graph based message-passing algorithms to estimate the variables of interest. For a given instance of a factor-graph, a message-passing algorithm (e.g. the sum-product algorithm) iteratively evaluates an estimate of the variable of interest (e.g. its marginal distribution given the observed data) by exchanging messages along edges of the graph. Sparse graphs, with many fewer edges to describe statistically related variables, lead to low-complexity message passing implementations. Finally, as data relevance and statistical structure becomes obvious (system graph and relevant inputs are known) then direct methods of information extraction and inference processing can be utilized.

2.2. Phase I Technical Objectives:

2.2.1. Development and initial testing of non-complex methods for predictive information processing on graphs.

2.2.2. Development and initial testing of "Graph Discovery" algorithms for dealing with system model uncertainty and reducing model complexity.

2.2.3. Development and initial testing of methods for data organization and representation

with big-data sets consisting of multi-source, multi-structure data.

2.2.4. Development and initial testing of methods for extraction of statistically relevant information for a given instance of a program/application

2.2.5. Development of a strategy for commercialization and Phase II proposal, including performance/cost estimates for the technology embodiment and Phase II Testbed plan.

2.2.6. All Reporting functions, including documentation of system framework, algorithms and development progress.

2.2.7. [Optional] Submit conference paper based on Phase I R&D efforts.

Part 3. Phase I Research Plan

The product concept developed in this proposal spans software and hardware domains. The software component is comprised of graph-based model discovery algorithms, message-passing (inference processing) algorithms on graphs, and human visualization/user interface software. The hardware component is comprised of radio-sensor processing terminals (e.g. radio-adapted laptops with audio and video sensors) and a radio collection/processing/UI terminal. We discuss the Phase I research plan in the subsequent sections listed below:

Section 3.1: Information Processing Strategy
Section 3.2: Overview of the Phase I Wireless Testbed
Section 3.3: Visualization/User Interface Components

Module	A	B	C	D
Name	Data Pre-Processing	Data Aggregation	Graph Discovery	Message-Passing
Description	De-noise/filter raw data inputs and map multi-source, multi-structure data to common base	Compress redundant data in base; extract relevant data for application/query instance	Identify key system variables and statistical relationships with graph based models	Application of message-passing algorithms, e.g. sum-product algorithm, for estimating unobserved variables

Table 1. Modules of the predictive information processing engine in proposal by Aquerre Technologies. In Phase I, we emphasize development of modules C and D, with additional emphasis on modules A and B in Phase II.

3.1. Information Processing Strategy

A primary contribution of this proposal is the use of factor-graph based system models as a basic framework for developing predictive information processing technologies. The application of factor graphs, message-passing algorithms and inference processing on graphs to engineering systems is an active topic of research and development. The P.I. has research experience on analysis, design and optimization of error control codes based on factor graph models and algorithms for inference processing on graphs [6] [5] [7]. See related papers [8] [9] [10] for details on graph-based models in systems engineering and error control coding applications. In this proposal we build upon our research expertise and the state of the art of systems engineering science to develop a proprietary graph-based predictive information processing strategy. Our information processing strategy is comprised of the modules summarized in Table 1. In this proposal we investigate a detailed development of modules C and D, with Phase I test bed validation and extensibility to large-scale Phase II testbed system. In the following subsections, we provide a brief overview of information processing modules A and B and a detailed discussion of modules C & D.

3.1.1. Data Pre-Processing (Module A)

This module includes the basic processes associated with filtering and mapping individual raw data streams to a common database. Our product will be designed to accommodate a diverse set of data-types, such as text, image, audio, and video. As new input data arrives, each input data type is written to its associated database structure during the pre-processing stage. If the raw input data is represented in an incompatible format, the pre-processing stage makes any necessary conversions and further discards any useless inputs, such as out-of-band signals. The common database maintained by Module A is used by all the of the predictive information processing modules (A-D) to perform their associated functions. We anticipate that the processes associated with Data Pre-Processing and data-set management will be increasingly important as the we scale our system to big-data environments. For the initial six-month Phase I R&D segment we plan to use standard data formats, open data tools, and reduced size data sets in order intensely focus on the information processing methods of Modules C and D.

3.1.2. Data Aggregation (Module B)

As advanced systems rely on an ever increasing supply of big-data to estimate trends and make predictions, methods of data aggregation and sub-selection are increasingly important. The Data Aggregation module (Module B) includes all processes associated with extracting statistically relevant information from the common base for a given instance of the application. The relatively simple proposed Phase I Testbed system will rely primarily on local sensor-network based measurements to make predictive estimates. We plan to demonstrate performance of the inference processing algorithms with a simple example such as predicting the path of a moving object. As a result, the need for large-scale data-aggregation is assumed to be minimal for the Phase I testbed segment and plan to address aggregation-based performance issues with a large-scale Phase II test system.

To get practical implementations for large scale systems, the algorithms developed in the Phase I segment will be evaluated in terms of computational complexity--as a function of the number of system variables. In addition, small-scale development testing will be conducted with the Phase I testbed. Our research plan includes the evaluation of a Quality-of-Relation (QoR) metric for data aggregation/extraction in big-data environments, based on low-order joint statistical moments of the system variables. The QoR metric is intended to identify statistical relationships between subsets of data. We initially propose to investigate the use of pairwise empirical correlation estimates between the input data sets. To illustrate the design approach, let Z_t denote a vector of the real-valued data inputs at sample t. The statistical auto-correlation matrix of the data, defined as $R=E[Z_t Z_t^T]$ (where E denotes the expectation operator) can be estimated by forming an empirical average: $\hat{R}=1/N\sum_{t=1}^{N} Z_t Z_t^T$. Supposing the matrix R is known, we can use the spectral theorem to write $R=V\Lambda V^T$, and identify the transformation matrices to reduce the system of input data to its dominant spectral components (variables). The goal of this approach is to transform the data to a representation of much smaller dimension with as little loss as possible (minimum mean squared error for a given number of output variables). In practice, it may not be possible to directly estimate the matrix R and thus we propose to investigate approximations/variations to the pairwise input correlation approach using the QoR metric mentioned earlier. Further levels of of aggregation may be desirable given the application instance, and this type refined data aggregation is performed in conjunction with the Graph Discovery module (Section 3.1.3.). (Hence, certain data aggregation functions are included as part of Module C.) Finally, adaptive updates to the QoR metrics and QoR based mining will be investigated for model learning, tracking non-stationary input data and dynamic program objectives.

3.1.3. Graph Discovery (Module C)

We use a graph-based model to describe the relationship between system inputs and outputs [9]. The graph is defined as a set of nodes and a set of links connecting the nodes. We consider a specific family of graphs, known as “bipartite graphs”. There are two types of nodes in bipartite graphs, “variable nodes” and “check nodes”. Moreover, the links of a bipartite graph may only connect a check node to a variable node. Variable nodes correspond to variables of the physical system. Check nodes represent statistical relationships between the variable nodes to which they connect. Both check and variable nodes may be either hidden (unobserved) or observed [6]. In this proposal, graph discovery algorithms are developed to uncover key system variables and statistical relationships. The module containing these algorithms is referred to as “Graph Discovery” in Table 1.

In Phase I we propose to investigate the generation of factor graph models using low-order moment based approximations to multi-variate characteristic functions. In this proposal we refer to the low-order joint statistical moments between system variables as “QoR metrics”. To motivate our approach, recall that the characteristic function of a random variable is defined as the inverse Fourier transform of its probability density function (PDF), and Taylor expansion of the characteristic function is given by a linear combination of the joint moments of the variables [11]. Thus, low order approximations to the system PDF can be obtained by estimating low-order moments of the systems variables. For example, consider a bi-variate pdf, $f_{XY}(x,y)$, of the real-valued random variables X and Y and let $\phi(\omega_{1,}\omega_2)=IFT(f_{XY}(x,y))$ denote the corresponding characteristic function (IFT denotes the two-dimensional inverse Fourier transform with frequency variables ω_1 and ω_2). A second-order Taylor expansion of ϕ yields:

$$f_{XY}(x,y)\approx FT\left[1+(i\omega_1)E[X]+(i\omega_2)E[Y]-(\omega_1^2/2)E[X^2]-\omega_1\omega_2 E[XY]-(\omega_2^2/2)E[Y^2]\right],$$

where FT denotes the two-dimensional Fourier transform operator. Hence we have obtained an approximation to the joint pdf f_{XY} based on a linear combination of the first and second order joint moments of variables X and Y .

The principle outlined above will guide our Graph Discovery algorithm development approach, based on the use of empirical estimates of low-order joint moments of system variables (QoR metrics). We plan use training based schemes to estimate the QoR metrics and evaluate their use as a metric for edge selection when “Discovering” the system factor-graph model. In summary, in this SBIR proposal we assume that some part of the underlying statistical structure of the predictive system must learned and we approach this issue using Graph Discovery methods that attempt to find low-complexity system representations.

3.1.4. Message-Passing Based Inference Processing on Graphs (Module D)

The predictive information processing algorithms developed in this program utilize the graph-based system models formulated in Graph Discovery module as a basic framework for information processing. Statistical inference processing can be implemented with “message-passing” algorithms on a factor-graph describing system input-output relationships [9] [12] . In this proposal, we investigate reduced-complexity representation based on sparse factor-graph models and quality-of-relation analysis. We propose to investigate the use of sparse graphs to capture key statistical relationships using reduced sets of variables. We claim that the use of fewer variables and sparse representations will lead to low complexity communication and control algorithms that scale well to large systems.

Description of the Algorithm Development Framework: To illustrate the proposed graphical development framework, we introduce the following mathematical notation: let X denote an event of gun violence in region A during time period B and let Y denote the observed data (crime data, news reports, etc.). In practice, Y could represent a big data set. Let $f(X,Y)$ denote the "global" joint Probability Distribution Function (PDF) of the variables X and Y. In general, the variables (X,Y) represent a large multi-variate set in which there exist statistically related and statistically unrelated variables. As a consequence, the global PDF $f(X,Y)$ factors into a product of component PDFs. Let us denote a factorization as:

$$f(X,Y)=\prod_{n=1}^{N} g_n(Z_n)$$

where Z_n denotes a subset of the variables (X,Y), $g_n(Z_n)$ denotes a joint PDF of the variables Z_n, and $n=1,\ldots,N$. The factorized global PDF can be represented by a "factor graph". The results summarized in [9] show that the global distribution $f(X,Y)$ can be computed using message passing algorithms (i.e. the sum-product algorithm) operating on a factor-graph corresponding to the factorized global PDF. For a given number of system variables, a factor-graph framework yields a simplification in processing complexity (less links between nodes) as compared to a general case model in which each system variable is assumed to be statistically related to every other system variable (most links between nodes). In practice, a factor-graph message-passing framework could be used to estimate any statistical quantity relating the variables X and Y, by the computing appropriate marginal distributions. For example, the marginal probability of the event X,

$$Pr(X)=\int f(X,Y)\,dY,$$

is readily estimated using outputs of the sum-product algorithm.

Note that factorizing the global PDF $f(X,Y)$ represents a process of complexity reduction since the underlying graph is used to implement the data processing algorithms and each edge corresponds to an additional N processing operations. Thus, finding a simple factorization of the global PDF, or some approximation, leads to more efficient algorithms that scale better to systems with a large number of variables. A key assumption is that we can determine a simple factorized PDF. In practice, this must be accomplished by appealing to physical/logical arguments, hypothesis evaluation, assuming a statistical distribution over unknown system variables, or some other means. In the Phase I development segment, methods for graph factorization and statistical relationship discovery are investigated as part of the Module B and Module C research plan.

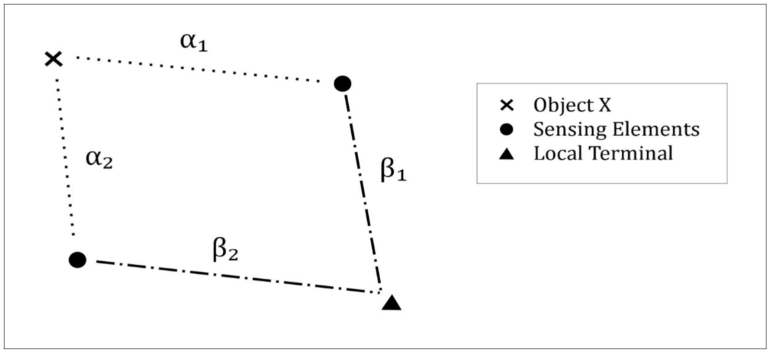

Fig. 2. Topology of the Phase I development testbed.

3.2. Overview of the Phase I Wireless Testbed

This proposal includes an experimental wireless sensor network testbed component for developing and testing the proposed information processing methods. The “Phase I Testbed” is planned to be relatively simple, consisting of at least three laptops equipped with Radio-Frequency (RF) transmitter/receivers and video/audio sensors. Note that our advanced system will employ a large number of sensors with multiple sensing modalities (RF, infrared, etc.). In this project, we propose to use the ISM frequency bands (2.4 GHz, 5.7GHz) for sending and receiving sensor-based data and other communication and control signals. We plan to use GNU Radio open software and compliant vendor hardware. The basic topology of the Phase I testbed is illustrated in Fig. 2. Our methods developed in Phase I will be demonstrated at the end of the six month segment with a simple Testbed-based example, such as cooperative predictive tracking of a moving object. As a measure of the system performance, we will demonstrate that cooperative predictive tracking is more accurate then non-cooperative tracking methods. A second example is cooperative detection of breach in threshold event.

A primary use of the Phase I sensor-radio network will be to develop the methods of “Graph Discovery” and “Message-Passing” (Modules C and D) of the information processing strategy discussed in Section 3.1. Phase I Testbed feedback will play a critical role in the development of the underlying modeling and algorithm implementation framework used in our methods. We do not anticipate a large volume data for the Phase I demo example due to the use of only a couple sensor terminals, with standard data formats. Therefore, for the Phase I Testbed, the modules of Data Pre-Processing and Data-Aggregation (Modules A and B) are assumed to be non-complex and a straight-forward consequence of the processes of Modules C and D. Note that algorithm complexity for systems with many variables will be treated in the Phase I segment by means of analysis and/or simulation of the large scale case. Hence the Phase I research plan directly addresses development of the methods of modules A and B, but development of a large-scale Testbed and focused testing activities of modules A and B of the information processing strategy are scheduled for Phase II.

In summary, the initial testbed system will be used to demonstrate a simple example of the predictive information processing methods developed in the Phase I segment. Our Phase I testbed R&D activities will play a key role in demonstrating a proof of technology concept while providing key insight into the way forward on the proposed large-scale Phase II Testbed and commercialization strategy.

3.3. Visualization/UI Components

We propose to tackle the challenge of data organization and display for large multi-source/multi-structure data sets using a 4-dimension “geo-spatial” (three spatial coordinates plus temporal coordinate) organization strategy. We claim that all data is intrinsically related to points or regions in space and time and therefore we can intuitively map any data to a 4-D space-time grid based on a location-time attribute (see e.g. [13]). In this proposal, we leverage a geo-spatial data organization strategy to support a 3-D virtual environment for program visualization and user interface. In particular, we propose to modify open software, based on code obtained from http://opensimulator.org, to render radio-sensor output data and program data. The Phase I development segment of this program will include primitive development work on the visualization/UI virtual environment, with advanced development activities in Phase II and beyond.

Part 4. Commercial Potential

4.1. The Market Opportunity

The development of high-performance error-control codes based on sparse graph models, factor graphs and inference processing algorithms has had a huge impact on modern technologies, from the proliferation of mobile wireless devices to the advancement of space exploration systems. Here, we advance the state of the art of predictive information systems technology for the application of gun control. A key market opportunity of interest to us is the security systems technology market. The anticipated customer is interested in advanced threat detection and situational awareness feedback data based on our automated control network processes. Moreover, we foresee the possibility of direct licensing of intellectual property generated in this SBIR program. A primary barrier to entry is the untimely delivery of product to market.

4.2. The Company/Team

Aquerre Technologies LLC is a Los Angeles based start-up company organized in May 2013 by founding member and Principle Investigator, Noah B. Jacobsen. Prior to founding Aquerre Technologies, Noah's experience includes six years of research and development experience with Alcatel-Lucent, Bell Labs and adjunct teaching appointments at Columbia University and Polytechnic Institute of NYU. Noah holds a Ph.D. from the University of California, Santa Barbara (2005), a U.S. patent for the design of a rate-compatible LDPC error-control code (2011) [7], and has several academic publications in the field of communications, control and signal processing. Noah's R&D experience emphasizes algorithms development, standardization, and transition to product. Aquerre Technologies development strategy similarly emphasizes theory-based development tracks with the goal of obtaining high-performance, cost-efficient implementations. In this program, our core strength expertise in systems engineering and coding theory will be leveraged to obtain an advanced graph-based predictive information system for the application of gun control.

Future outlook: Aquerre Technologies LLC seeks to establish itself as a global leader in predictive information systems and security technology. We are seeking to grow our Los Angeles based enterprise, including establishing office space and hiring full-time employees, primarily through SBIR contract applications. Los Angeles is a great city to live and work in, and we seek to strengthen our connection to the local community and beyond. Our company seeks to leverage a unique local and global perspective to provide valuable business services and technologies to our customers.

4.3. Product/Technology and Competition

Our product concept is a security network technology consisting of sensor-radio terminals, networked data exchange, and advanced predictive information processing methods, designed specifically for the application of gun control. A key strategic goal is the commercialization of a security technology for schools, universities, and government buildings. The value proposition offered by our product is the potential to prevent and mitigate events of gun violence. We are unaware of any competing products for the application of gun control based on an internet of things concept and plan to pursue any possible patent rights for the research conducted in this SBIR program. A critical milestone to commercialization is demonstration of a proof of concept with the large-scale testbed.

4.4. Financing and Revenue Model

Aquerre Technologies is organized as an LLC in the state of California as of May 2013. We're seeking to grow our enterprise through Small Business Innovation Research (SBIR) contracts. Our revenue model includes software-as-a-service, consumer hardware/software technology sales, intellectual property licensing, and consulting and research services.

Part 5. Consultants and Subawards/Subcontracts

5.1. This proposal does not directly include any consultants.
5.2. There are no sub-awards or sub-contracts to this proposal.

Part 6. Equivalent or Overlapping Proposals or Awards to/from Other Federal Agencies

6.1. Aquerre Technologies has a concurrent Phase I SBIR proposal with the Office of Naval Research (ONR). These two proposals are non-equivalent in the sense that they describe different system embodiments, however there is some overlap in the underlying system modeling and algorithm development framework. Additional details are available on request.

Part 7. Lineage of the Innovation

7.1. The proposed work has connections to the following NSF award:

- Directorate Name: Office of International and Integrative Activities (IIA)
- Division Name: NSF East Asia Summer Institutes for US Graduate Students
- Award Number: 310419 (2003)
- P.I.: Noah B. Jacobsen (UCSB)
- Description of the innovation: This NSF award included the investigation of interference suppression algorithms for ultra-wideband (UWB) communication systems. In collaboration with Yokohama National University (YNU), Japan, we applied Low-Density Parity-Check (LDPC) codes and iterative Bayesian signal processing methods to mitigate severe inter-symbol interference characteristic of UWB radio-propagation channels. The methods developed at YNU are indirectly related to the methods described in this proposal. Specifically, some of the graph-based algorithms (factor-graphs and the sum-product algorithm) applied in this proposal were initially developed as part of previous work performed with YNU.

Part 8. Documents Referenced in this Proposal

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