Smart Sensor Engineering based on Brainlike Technology

Recent advances in environmental, equipment, and human health monitoring sensors, along with telemetry that allow them to operate remotely, are spawning today's wireless revolution [1-2]. While the wireless sensing market is growing quickly [3], its growth will become even stronger once smart sensing technology has matured. Smart sensors will include deployable processes that can reduce sensor data to useful information in real time before it is transmitted [4], along with engineering services that will allow them to be configured and integrated affordably [4-5]. Thus, emerging smart sensor systems will be made up of three components: physical sensing devices, remote sensor telemetry, and real time signal processing upstream of telemetry. Smart sensor services will allow smart sensors to be developed, evaluated, configured, and integrated, quickly, efficiently, and effectively.

Smart Sensing Value

Smart sensing processes and analysis procedures speed sensor engineering and reduce delivery costs by automating the data analysis process. Smart sensing processes automatically and continuously correct for changing conditions, making them more robust than conventional systems. Further, the analysis process itself can also be streamlined to identify optimal alternatives more precisely. Thus, engineering costs can be reduced and delivery can be accelerated by meeting two basic needs:

- Delivering processing modules that are proven, dependable, robust, and broadly configurable to meet general purpose, smart sensing needs.
- Delivering analysis tools that include simple, automated procedures for rapidly identifying processing configurations that will reduce sensor data to valuable information.

In recent years, Brainlike, Inc. has been developing specialized products and procedures to satisfy both needs. To meet processing needs, Brainlike Processor™ solutions identify interesting events that have occurred, while filtering out clutter and unimportant information [1,4]. These solutions have been designed to be robust, by continuously and automatically adapting to changing background and clutter conditions, and compact, for efficient operation at remote sensor arrays.

Brainlike Processor™ has been designed to meet general purpose sensing needs, by offering a variety of feature functions that transforms raw sensor data to useful information in real time. Within each time slice, the process operates in successive stages that may perform any or all of the following operations:

1. Identifying an operational input data model. Brainlike sensing organizes input data into cells. Each cell can contain any number of input values. Cells may be

organized along one, two, or three space dimensions. These data organization alternatives allow for Brainlike sensing solution configurations suitable for most sensing applications.

2. Identifying an operational feature model. Brainlike sensing allows input data values to be transformed into feature values, which may be tailored to suit most sensor requirements. Specialized feature values may be used to identify and mask background clutter or to identify and flag events of interest, or both. Feature values may be based on cell windows, containing input values from nearest neighbors in space and time, making real time processing manageable.
3. Continuously adapting features to changing conditions. Brainlike sensing automatically updates learned feature metrics and adjusts feature values for changes. Doing so results in smart sensing solutions that are fast, simple, and robust.
4. Masking and ignoring uninteresting clutter. Brainlike sensing filters clutter by relying on adaptive thresholds for clutter feature values. Resulting filtered information is less costly to transmit and better suited for identifying interesting events.
5. Identifying target events of interest. Brainlike sensing scans filtered data to identify events of interest, relying on adaptive thresholds for target feature values. Resulting alerts contain fewer false alarms and more valid detections that are robust against changing conditions.

The Brainlike Studio™ toolkit has been developed to meet the analysis need. The toolkit runs Brainlike Processor™ with a variety of configurable models on historical datasets, identifying metrics that meet each of the above needs. Once a dataset has been gathered, the toolkit can produce output for evaluating each alternative model quickly. In the process, a variety of sophisticated but automated techniques can be used by analysts with minimal Brainlike training.

Without Brainlike Processor™ systems and the Brainlike Studio™ toolkit, highly trained signal processing experts would require much more time to model sensing data. What is worse, engineers could refine and deploy sensors and signal processing algorithms only after the experts had completed extensive analyses, development, testing, evaluation, and integration. This historically expensive and time consuming process is what the Brainlike Studio™ toolkit and Brainlike Processor™ systems have been designed to replace.

Smart Sensor Engineering Steps

How can smart sensor engineering deliver strong business value, quickly and affordably? Here are four basic steps:

1. **Identify system value.** How will the system increase benefit to the system operator? What type of events of interest must be identified during system operation? How will the system respond to these events? Will the system save money by reducing telemetry costs, increasing remote sensor life, reducing false alarm costs, simplifying analysis, or in some other way? How can value metrics be used to quantify added value? How much added value is worthwhile?
2. **Obtain a dataset for quantifying added value.** The dataset should include representative background clutter that must be masked, along with interesting events that must be detected. Since this dataset will be used to establish a smart sensing model, it should reflect operational reality over as many anticipated conditions as possible.
3. **Establish and evaluate an operational model.** Brainlike Studio™ provides engineers and analysts with the capability to tune the Brainlike process for a given system. Tuning tends to occur for a given system application. For example, a model may be tuned for identifying land mines from a video camera on an unmanned aerial system (UAS); a separate model may be tuned for identifying whales using radar; and yet another model may be used to identify irregular heartbeats from a cardiac sensor.
4. **Integrate and deploy the smart sensor system.** Once an operational model has been established, the Brainlike Processor™ can be configured and delivered into the smart sensing platform through its easy-to-interface API. Brainlike processing code is written in low-level C within a Linux environment, allowing it to be easily integrated into most computing environments — from servers at surveillance operations centers to microprocessors on remote sensor transmitters.

Brainlike, Inc. stands ready to engineer solutions that may satisfy any variety of smart sensing needs. For details, please contact us.

References

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