NDIA Army Science and Technology Conference

EWA Government Systems, Inc.

Biologically-Inspired Processor for Ultra-Low Power Audio and Video Surveillance Applications

Presented by Lester Foster and Dirk Niggemeyer

Company EWA Government Systems Inc.

- Electronic Warfare Associates (EWA) Inc., was founded in 1977 to perform electronic warfare assessments for the US Government and transformed into a subsidiary EWA Government Systems Inc. in 2002.
- Our semiconductor development technology was developed in response to the challenge described in the **Army SBIR topic no. A12-106, entitled "Bio-Inspired Semiconductor Technology."**
- We have approximately 200 members on staff across multiple subsidiaries and joint ventures.
  - Small Veteran-Owned Business (SVOB)
- EWA CEO and Founder: Carl Guerreri
- EWA GSI Subsidiary President: Brian Moore
- EWA and EWA GSI Chief Technology Officer: Lester Foster, Ph.D.
- EWA Principal Engineer: Dirk Niggemeyer, Dr.-Engr.

Problem/Opportunity

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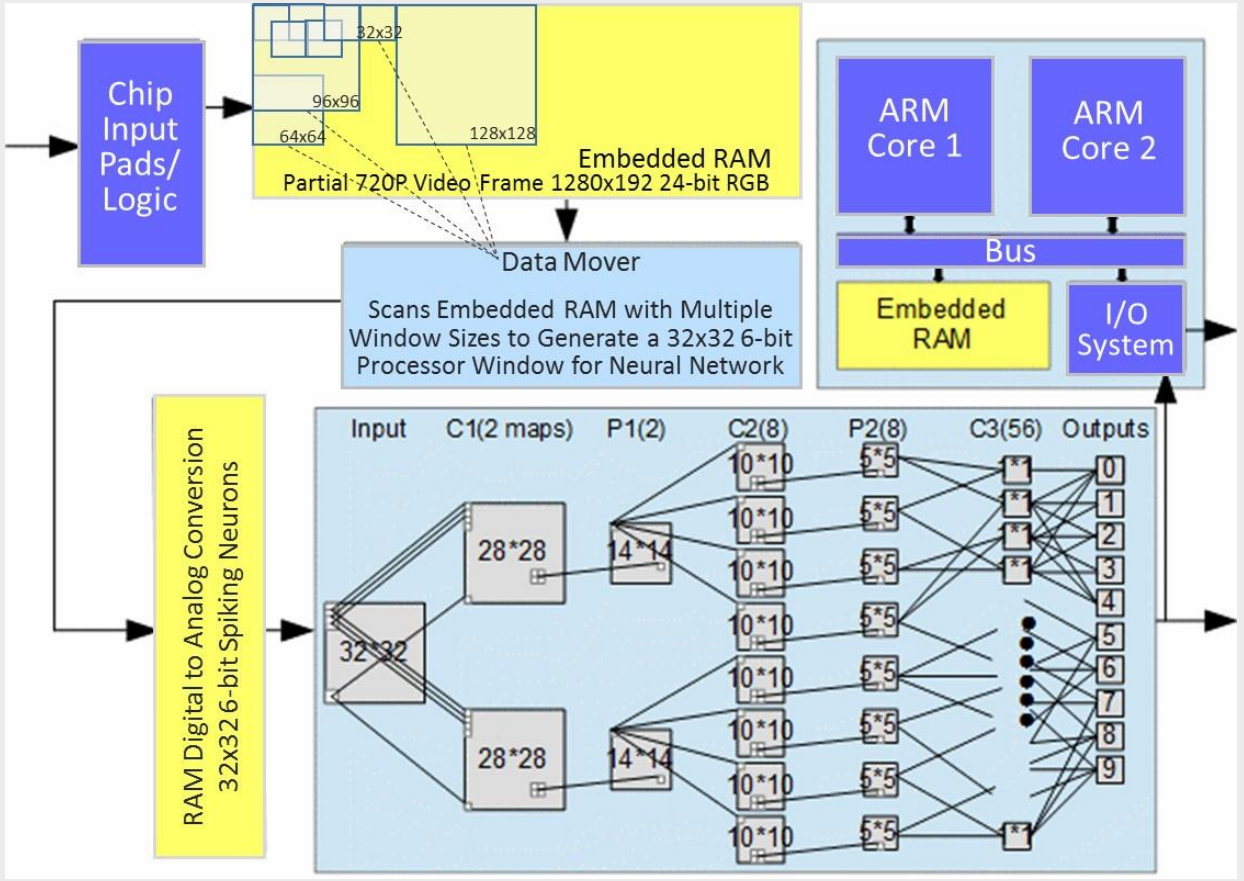
- Audio and video pattern recognition for surveillance applications
  - Classify sensor output to known patterns to identify content of interest.
  - Autonomous target classification and identification.
  - Useful with defense, security and law enforcement applications.
- Neural Network solutions successfully demonstrated pattern recognition
  - Employ processes similar to mammalian brain activities.
  - Implementation in software on standard processors requires substantial memory and power ("Brute Force" processing).
  - Excessive processor power required (10s of watts); not battery friendly.
  - Excessive training data required before networks can be deployed.
- Current processor technology utilizes transistors & Boolean binary logic
  - Reached the end of Moore's Law (IC performance doubling every 18 months).
  - New approaches are required to increase computer processing performance.

➢ Opportunity for new processors based upon neural networks

Technology

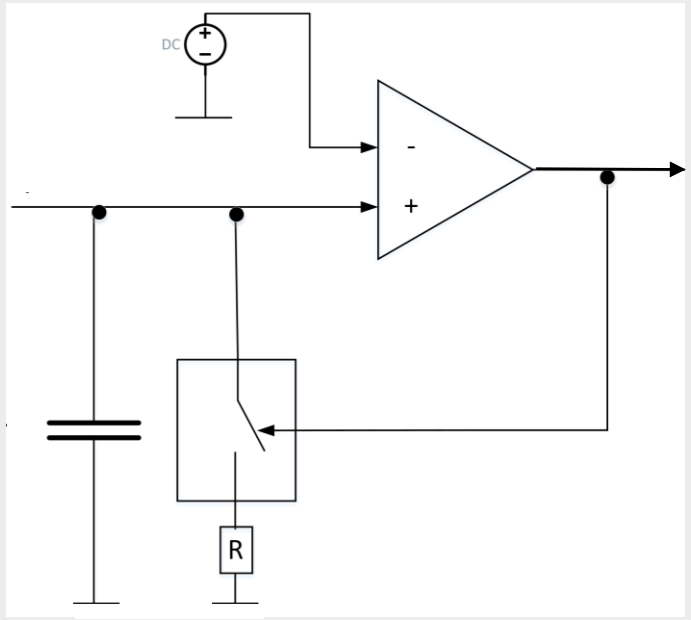
Compact Artificial Neural Network (ANN) Integrated Circuit Processor Core

- Compact ANN topology capable of 2-D circuitry layout employing a 32x32 pixel processing tile
  - Processing tiles scan across entire image for image recognition.
  - Larger tiles can be downscaled into processing tile during image scanning.
  - Processing tiles scan audio spectral plots of overlapping short time increments.
- Memristors, a new electronic device, are used to program processor to correlate patterns.
- Integrated with conventional processors, e.g., ARM cores, for hybrid multicore processing.
- **Potential to turn dumb cameras and audio collection sensors into smart low-power sensors.**



Architecture of the ANN Processor as a separate core with video input pre-processor of a multi-core processor

Key is Spiking Neuron



- Spiking neuron transmits information across neural network similarly to mammalian brain
  - Upstream currents and pulses build charge and voltage on capacitor until threshold voltage is reached on transistor.
  - Transistor fires short pulse which also flips switch to dump capacitive voltage to ground and resets the neuron.
  - Higher frequency spiking rate implies brighter pixel in image processing on input layer.
- Convolutions in digital logic reduce to additions of spikes
  - Replacing convolutions with weighted additions drastically reduces the power consumption of the neural network.
- Energy within each spike is very small: femtojoules (10^{-15})
- We have patented the conversion of digital data into spiking analog signals for spiking neural processing
  - We are now optimizing the digital logic, e.g., data mover, to further reduce power consumption of the overall system.

Concepts for Use

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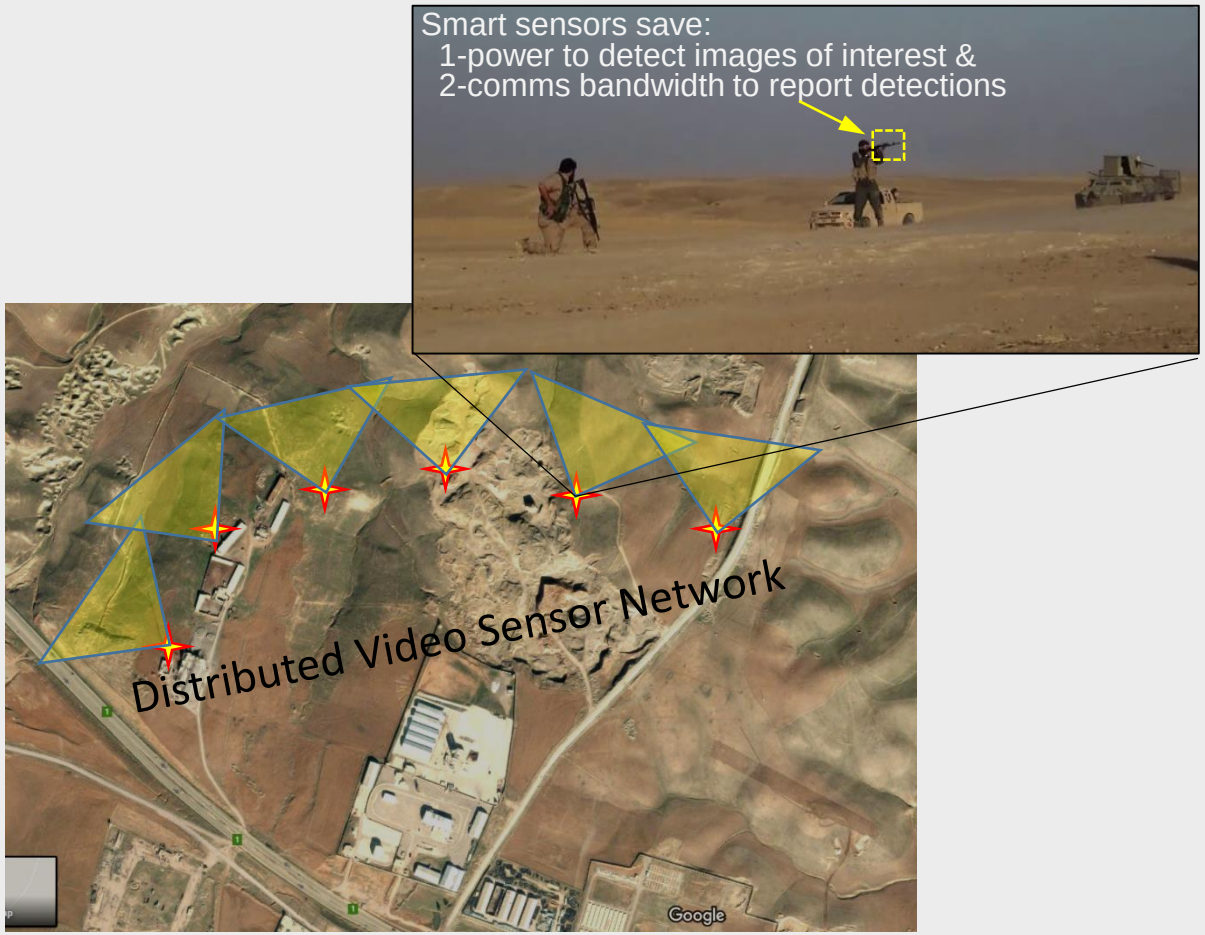
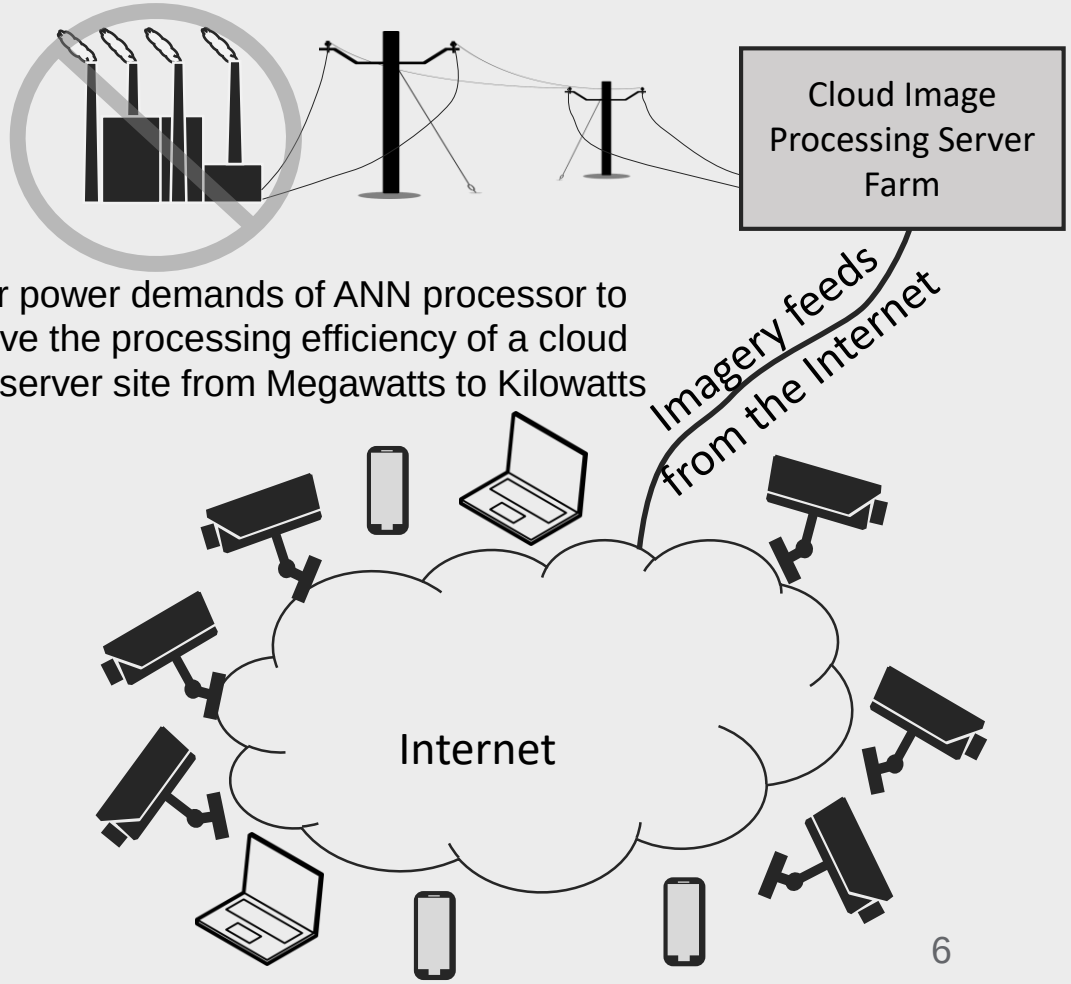
Smart Video Sensor Networking Applications



Intelligence and Law Enforcement Applications



Results to Date

- Revolutionary ANN processor design
  - Two patents to cover unique features of design.
- Ultra low power pattern recognition processing
  - Image processing only requires tens of milliwatts to process imagery for objects of interest.
  - Most power is consumed in the input digital data conversion to analog spiking signals of neural processing.
  - Minimal power processing through network.
- Software application to train or “program” pattern recognition into ANN processor core
- Convert dumb sensors to smart sensors
  - Image processing at camera source eliminates imagery data overloads on networks.
  - Processing power negligible compared to sensor.
  - Lower comms bandwidth to relay only interesting data.
- Processor can be integrated in any platform from smartphones to video and audio collection processing servers

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Images used to train the ANN to recognize AK-47 Rifles from random pictures off the internet

Performance: Probability of Detection at 90%

Comparison to Conventional Processors

EWA GSI's ANN Processor Solution	High End Conventional Technology Approach
Artificial Neural Network (ANN) Processor programmed with training application	Conventional multi-core processor with operating system and state-of-the-art Yolo-2 pattern recognition application
Fast processing of imagery, 1 microsecond to process 32x32 pixel image tile	Real-time processing requires significant processing power
Spiking neurons and network synapses	Neural network coded with conventional software
<33 milliwatts to process 720P HDMI video at 60 frames per second	10s of watts to process 720P HDMI video at 60 frames per second
Demonstrated 90% probability of detection for targeted items	Probability of detection was estimated at 78%

ANN Development Team

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- ANN Processor Core Development Team Key Players:
  - Program Manager and Chief Technology Officer: Lester Foster PhD (EWA GSI)
  - Principal Investigator and Principal Engineer: Dirk Niggemeyer, Dr.-Engr. (EWA GSI)
  - ANN Consultant and President: Elizabeth Rudnick PhD (Imaginic, Inc.)
  - Memristor Research Lead and Associate Professor: Nathaniel Cady PhD (University of Albany, SUNY)
- Our team is sufficient & complete to develop the revolutionary ANN processor to TRL 6

Contact

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