Center for Embedded Systems
An NSF Industry/University Cooperative Research Center

Center for Embedded Systems (CES)
Request for Proposals Template – YEAR 5

DUE: Monday, April 8, 2013, by 5 p.m.

TITLE:	**Registration and Fusion of EVS and SVS Runway Images for Embedded Systems**			
PI:	Lalit Gupta	**EMAIL:**	lgupta@siu.edu	**TEL:**(618)4537032
DEPT:	Electrical & Computer	**SCHOOL:**	SIUC	

ABSTRACT: (250 OR FEWER WORDS)

Safely landing an aircraft on a runway in all weather conditions requires fusing information from various sensors. The goal of this project is to develop algorithms to accurately register runways in EVS and SVS images and fuse the registered images so that the information from both images are displayed simultaneously. The registration of runway images will be based on detecting corresponding features in both images. The features will be extracted from the Hough transform of the images and will typically consist of the four corner points of the runway quadrilaterals. Image fusion will be based on combing the discrete wavelet transform (DWT) coefficients of the images. Several combinations rules such as the maximum, average, and a combination of the maximum and averaging of DWT coefficients will be evaluated. The final goal will be to improve the computational efficiency by embedding the algorithms into a multi-core processing architecture.

PROBLEM:

This project will focus on developing a sequence of novel algorithms to safely land aircrafts by registering the runways in EVS and SVS images and fusing the registered images so that the information from both images can be optimally displayed. Image registration and image fusion are quite complex problems and the main challenge is when the quality of the EVS image is poor due to poor weather conditions. This makes the extraction of features difficult and, therefore, has an adverse effect on the registration which subsequently results in poor fusion results. Furthermore, the varying dimensions and the varying 3-dimensional angles of the runway in the sequence of images increase the complexity of the problem quite significantly. Real-time registration and fusion also requires processing vast amounts of data very rapidly. Another challenge, therefore, is to overcome the processing burden that is inherent to this problem.

RATIONALE:

The precise detection of runways is crucial for safely landing manned and unmanned aircrafts. The challenge is to be able to detect the runway accurately in all possible weather conditions. A novel approach which involves registering and fusing EVS and SVS images is proposed. A successful completion of this project will have a major impact on improving landing safety.

APPROACH:

The approach that will be followed to achieve the final goal of the project will be to develop and test the sequence of algorithms to register and fuse EVS and SVS images. Specifically, the algorithms will be developed in the following order:

(a) EVS line detection: develop kernels to adaptively extract lines in specific orientations.
(b) EVS segmentation: develop algorithms to autonomously segment images consisting of line segments [1],[2].
(c) EVS runway line detection: select dominant lines that form the runway sides from the Hough transform of the line image.
(d) EVS runway corner detection: detect intersecting line segments from the Hough transform.
(e) SVS segmentation: develop an adaptive segmentation algorithm.

(f) SVS runway line detection: select dominant lines that form the runway sides from the Hough transform of the line image.
(g) SVS runway corner detection: detect intersecting line segments from the Hough transform.
(i) EVS and SVS image registration: develop algorithms to register EVS and SVS images based on the corresponding runway quadrilateral tie-points in the pair of images.
(k) EVS and SVS image fusion: develop DWT based method for fusing EVS and SVS images.
(l) Evaluate the entire sequence of algorithms on image sequences provided by Rockwell Collins.
(m) Investigate computational issues related to real-time applications.
(o) Embed the selected algorithms into a multi-core processing architecture for real-time systems.

NOVELTY:

Many techniques to register and fuse images already exist. This project, however, will focus on problems that have been uniquely identified by Rockwell Collins. It is expected that the techniques developed in this project will not only lead to the development of novel landing heads-up display system but will also be applicable to a vast range of problems involving image registration and image fusion.

POTENTIAL BENEFITS TO INDUSTRY MEMBERS:

Rockwell Collins will define the runway detection problems of interest to them and SIUC will provide them with the technical background and algorithms to solve the problems.

DELIVERABLES:

Deliverables

(a) Technical background into image registration and image fusion.
(b) The complete ensemble of algorithms to register and fuse EVS and SVS runway images.

TIMELINE/MILESTONES: (PER QUARTER)

Year 2: Complete items (a) through (l) listed in the Approach section.
Year 3: Test, evaluate, and improve algorithms developed in (a) and (l)
Year 4: Complete item (o) and investigate new applications.

TECHNOLOGY TRANSFER:

Upon completion of the project, the potential for technology transfer will be quite high because we will have developed new techniques for image registration and fusion.

BUDGET:

Direct cost: $25,000/year
$19,368 to support a PhD student @50% for 12 months, and $5,632 for PI salaries and travel.

BIBLIOGRAPHY: (ATTACH IN IEEE CONFERENCE OR JOURNAL FORMAT)

1. L. Gupta and T. Sortrakul, "A gaussian mixture based image segmentation algorithm," *Pattern Recognition*, vol. 31. No. 3, 315-325, l998.
2. R.C. Gonzales and R.E. Woods. Digital Image Processing. Prentice Hall, 2008

PI INFORMATION: (ATTACH 2-PAGE CV)

Lalit Gupta
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Education

- Ph.D. Electrical Engineering, Southern Methodist University, Dallas, Texas, l986.
- M.S. Electrical Engineering (Digital Systems), Brunel Univerity, Uxbridge, England, l981.
- B.E. (Hons.) Electrical Engineering, Birla Institute of Technology and Science, Pilani, India, l976.

Academic Experience

- Professor, Department of Electrical and Computer Engineering, Southern Illinois University, Carbondale, Illinois, July 2001 present.
- Associate Professor, Department of Electrical Engineering, Southern Illinois University, Carbondale, Illinois, July l992 June 2001.
- Assistant Professor, Department of Electrical Engineering, Southern Illinois University, Carbondale, Illinois, June l986 June l992.

Professional Associations

- Associate Editor, Pattern Recognition Journal (5-year journal impact factor: 3.402).
- Senior Member, Institute of Electrical and Electronics Engineers.
- Member, Pattern Recognition Society.
- Member, American Society for Engineering Education.

Research Interests

Pattern Recognition, Multi-dimensional Signal Processing, and Neuroinformatics.

Recent External Funding

1. L. Gupta, "Seizure analysis and prediction (Phase I; NIH/SBIR)," Cleveland Medical Devices subcontract, 5/15/03 5/14/04.
2. L. Gupta, "Seizure analysis and prediction (Phase II; NIH/SBIR)," Cleveland Medical Devices subcontract, 4/1/04 3/31/05.
3. L. Gupta, "An ear device for hands free wheelchair control (Phase I, NIH/SBIR)," Think-A-Move Ltd. subcontract, 9/1/03 5/1/04.
4. L. Gupta, "Online database and analysis system for ERP screening (1)," Neuronetrix, 1/1/05 8/15/05.
5. L. Gupta, "Online database and analysis system for ERP screening (2)," Neuronetrix, 6/1/05 12/31/05.
6. L. Gupta, "An ear device for hands free wheelchair control (Phase II, NIH/SBIR)," Think-A-Move Ltd. subcontract, 6/1/05 5/15/06).
7. L. Gupta, "Human-Machine Interface System for Hands-Free Robot Tele-Operation", Naval Postgraduate School, 8/7/06 - 12/30/06.
8. H. Sevim, L. Gupta, J. Mathias, K. A. Pericak-Spector, J. Tezcan, "Engineering and Technology Talent Expansion Program at Southern Illinois University", NSF, 9/15/06 - 8/31/10.
9. L. Gupta, "Color-agnostic dropout of document background," California Testing Bureau/McGraw Hill (funding approved for 5/15/2012 – 5/14/2013).
10. L. Gupta, "Object identification and tracking," NSF Center for Embedded Systems, (5/15/2012 – 5/14/2013).

Recent Journal Publications

1. J. Phegley, K. Perkins, L. Gupta, & L. Hughes, "Multi-category prediction of multifactorial diseases through risk factor fusion and rank sum selection," *IEEE Transactions on Systems, Man, & Cybernetics A*, Vol. 35, No. 5, 718-726, September 2005.
2. L. Gupta, H. Kook, D.L. Molfese, & K.C. Fadem, "Multi-stimuli multi-channel data and decision fusion strategies for dyslexia prediction using neonatal ERPs," *Pattern Recognition*, Vol. 28, No. 11, 2174-2184, 2005.
3. L. Gupta, B. Chung, M.D. Srinath, D.L. Molfese, & H. Kook "Multi-channel fusion models for the parametric classification of differential brain activity," *IEEE Transactions on Biomedical Engineering*, Vol. 52, No. 11, 1869-1881, 2005.
4. R. Vaidyanathan, B. Chung, L. Gupta, H. Kook, S. Kota, & J. West, "A tongue-movement communication and control strategy for hands-free human-machine interfaces," *IEEE Transactions on Systems, Man, & Cybernetics A*, 533-546, July 2007.
5. R.Vaidyanathan, M.Fargues, R.S. Kurkan, L. Gupta, S. Kotta, R.D. Quinn, & D. Lin, "A Dual-Mode Human-Machine Interface for Robotic Control based on Acoustic Sensitivity of the Aural Cavity*," International Journal of Robotics Research*, Special Issue, November 2007.
6. H. Kook, L. Gupta, S. Kota, D. Molfese, & H. Lyytinen, "An Offline/Real-Time Artifact Rejection Strategy to Improve the Classification of Multi-channel Evoked Potential," *Pattern Recognition*, vol. 41, no. 6, pp. 1985-1996, 2008.
7. R. Vaidyanathan, T. S. Prince, M. Modarreszadeh, L. Gupta, & F. J. Lisy, "Computationally Efficient Predictive Adaptive Control for Robotic Operation in Dynamic Environments and Task Domains," *Proceedings of the Institution of Mechanical Engineers*, Part B, Journal of Engineering Manufacture, 222, 12, 1695-1713, 2008.
8. S. Kota, L. Gupta, D. Molfese & R. Vaidyanathan, "A dynamic channel selection strategy for dense array ERP classification," *IEEE Transactions on Biomedical Engineering*, vol. 56, no. 4, 1040-1051, 2009.
9. U.B. Karangula, M.A. Kassem, L Gupta, H. El-Shemy, & D.A. Lightfoot, "Locus Interactions Underlies Seed Yield In Soybeans Resistant to *Hetrodera glycines*," *Current Issues in Molecular Biology*, 11 (Suppl. 1) i73-84, 2009.
10. M. Mace, R. Vaidyanathan, S.Wang, & L. Gupta, "Tongue in Cheek: A Novel Concept in Assistive Human Machine Interface", Journal of Assistive Technologies, vol. 3, pp. 14-26, 2009.
11. L. Gupta, S. Kota, S. Murali, D. L. Molfese, and R. Vaidyanathan, "Feature Ranking Strategy to Facilitate Multivariate Signal Classification," *IEEE Transactions on Systems, Man, and Cybernatics C*, vol. 40, no. 1, PP. 98-108, 2010.
12. L. Gupta, S. Kota, P. Yarlagadda and D. L. Molfese, "Central-Tendency Estimation and Nearest-Estimate Classification of Event Related Potentials," *Pattern Recognition*, Vol. 44-7, 1418-1425, 2011.
13. K. A. Mamun, M. Mace, L. Gupta, C. A. Verschuur, M. E. Lutman, M. Stokes, R. Vaidyanathan, S. Wang, "Robust Real-time Identification of Tongue Movement Commands from Interferences," *Neurocomputing*, 80, pp 83-92, 2012.
14. Y. Nanyam, R. Choudhary, L. Gupta L, J. Paliwal, "A Decision-Fusion Strategy for Hyperspectral Fruit Inspection," *Biosystems Engineering*, Vol. 111, 118-125, 2012.

Ph.D. Dissertation Supervision

Ravi Tammana, June 1994; Thotsapon Sortrakul, September l995; Mark McAvoy, September 1998; J. Phegley, Summer 2001; Beom S. Chung, Summer 2004; Hyunseok Kook, December 2006; S. Kota, December, 2010; M. Kelsey, May 2011.

I/UCRC Executive Summary - Project Synopsis		Date: 4/8/2013
Project Title: **Registration and Fusion of EVS and SVS Runway Images for Embedded Systems**		
Center/Site: SIUC		
Principle Investigator: Lalit Gupta		**Type: (New or Continuing)** Continuing
Tracking No.: (CES office to input)	**Phone :** 618-453-7032	**E-mail :** lgupta@siu.edu
		Proposed Budget: $25,000

Abstract: Safely landing an aircraft on a runway in all weather conditions requires fusing information from various sensors. The goal of this project is to develop algorithms to accurately register runways in EVS and SVS images and fuse the registered images so that the information from both images are displayed simultaneously. The registration of runway images will be based on detecting corresponding features in both images. The features will be extracted from the Hough transform of the images and will typically consist of the four corner points of the runway quadrilaterals. Image fusion will be based on combing the discrete wavelet transform (DWT) coefficients of the images. Several combinations rules such as the maximum, average, and a combination of the maximum and averaging of DWT coefficients will be evaluated. The final goal will be to improve the computational efficiency by embedding the algorithms into a multi-core processing architecture.

Problem: This project will focus on developing a sequence of novel algorithms to safely land aircrafts by registering the runways in EVS and SVS images and fusing the registered images so that the information from both images can be displayed optimally.

Rationale / Approach: The precise detection of runways is crucial for safely landing manned and unmanned aircrafts. The challenge is to be able to detect the runway accurately in all possible weather conditions. A novel approach which involves registering and fusing EVS and SVS images is proposed. A successful completion of this project will have a major impact on improving landing safety.

Novelty: The project will focus on problems that have been uniquely identified by Rockwell Collins. It is expected that the techniques developed in this project will not only lead to the development of novel landing heads-up display system but will also be applicable to a vast range of problems involving image registration and image fusion.

Potential Member Company Benefits: Rockwell Collins will define the specific registration and fusion problems of interest to them and SIUC will provide them with the technical background and algorithms to solve the problems.

Deliverables for the proposed year: Image registration and image fusion algorithms.

Milestones for the proposed year: Develop algorithms to:

(a) Register EVS and SVS runways in a sequence of images in varying weather conditions.
(b) Fuse registered EVS and SVS images in the DWT domain.
(c) Evaluate the various registration and fusion algorithms on data provided by Rockwell Collins.

Progress to Date: **THIS SECTION TO BE UPDATED IN JANUARY**

Estimated Start Date: August 2013	**Estimated Knowledge Transfer Date**: August 2014