

## **Hanumant Singh**

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### **Research Interests**

My interests include system architecture and algorithms for high resolution acoustic and optical imaging; underwater vehicle (AUV and ROV) system architectures for navigation, docking and power; and the interactions between these subsystems.

### **Education**

Ph. D., Massachusetts Institute of Technology/Woods Hole Oceanographic Institution Joint Program, 1995.

B.S., Computer Science, George Mason University, VA, 1989. *Distinguished Graduate*

B.S., Electrical Engineering, George Mason University, VA, 1989. *Distinguished Graduate*

### **Professional Activities**

Member of the Management Board, Engineering Research Center on Subsurface Sensing and Imaging.

Member, WHOI Alumni/ae Committee, 00-05.

Seminar coordinator, Dept of AOPE, 96-00.

Organizer, WHOI AUV Summer Seminar Series, 98.

Member, Task Force on International Arrivals, 93-95.

Student Representative, MIT-WHOI Joint Program, 93-94

Member, Educational Assembly/Educational Council, MIT-WHOI Joint Program, 93-94

Member, IEEE

Member, American Geophysical Union

Member, Eta Kappa Nu, National Honor Society for Electrical Engineering

Member, Alpha Chi, National Honor Society

in the Deep Sea, MIT, Cambridge, January, 1999.  
Sarnoff Research Labs, Princeton, NJ, November 1998.  
Naval Underwater Warfare Center, June 1997  
George Mason University, VA, 1996  
Massachusetts Institute of Technology, MA, 1995

## Students

### *Graduate and undergraduate students*

#### *Current*

Oscar Pizarro, Graduate Student, Mosaicking and optical navigation  
Chris Roman, Graduate Student, Multisensor fusion of underwater data  
Ryan Eustice, Graduate Student, 3D image reconstruction underwater  
\*Qiao Hu, Graduate Student, Pattern Recognition

#### *Past*

Rajesh Nadakuditi, Summer Student Fellow, Automated mosaicking of optical imagery.  
\*\*Jane Canulette, Summer Student Fellow, Architectural issues in AUV design.  
Gregory Fries, Summer Student Fellow, Docking for the Autonomous Ocean Sampling

### Networks

\*\*Frank Weyer, Graduate Student, Stereo Imaging with ABE  
\*\*Lt Cmdr Phil LeBas, USN, Master's Thesis, Control of an AUV at low speeds  
\*\*Lt Erik Burian, USN, Master's Thesis, Gradient Following with ABE  
\*\*Ralf Bachmayer, Undergraduate Thesis, Bottom Following with ABE

\*Co-advised with Cabell Davis  
\*\*Co-advised with Dana Yoerger

## Patents

1. Bales, J., Bellingham, J. G., Bradley, A., Liberatore, S., van Mierlo, F., Singh, H.  
Provisional patent for Safe Deep Ocean Pressure Compensated Batteries, Aug, 2000.

## Refereed Publications

1. Whitcomb, J. L., Yoerger, D. R., Singh, H., Howland, J. Advances in underwater robot

Omnidirectional Homing”, Accepted by the Journal of Oceanic Engineering.

5. Singh, H., Moran, B., Bellingham, J., Lerner, S., von der Heydt, K., “Docking for AOSN Part II - Autonomous Docking”, Accepted by the Journal of Oceanic Engineering.

6. Ballard, R.D., McCann, A., Yoerger, D., Whitcomb, L., Mindell, D., Oleson, J., Singh, H., Foley, B., Adams, J., Piechota, D., “The Discovery of Ancient History in the Deep Sea Using Advanced Deep Submergence Technology”, accepted by the Journal of Deep Sea Research.

7. Whitcomb, L., Yoerger, D., Singh, H., Mindell, D., “Towards Precision Robotic Maneuvering, Survey, and Manipulation in Unstructured Undersea Environments”, *Robotics Research - The Eighth International Symposium*, Springer Verlag Publications, Berlin, 1998

8(a). Tivey, M., Yoerger, D., Bradley, A., Catanach, R., Duester, A., Liberatore, S., Singh, H., "Autonomous Underwater Vehicle Maps Seafloor", *EOS, Transactions of the American Geophysical Union*, vol 78, no 22, June 1997.

(b) Also selected for publication in a journal for high school teachers and students, Tivey, M.A., A. Bradley, D. Yoerger, R. Catanach, A. Duester, S. Liberatore and H. Singh, Autonomous underwater vehicle maps seafloor, *Earth in Space*, 10, 10-14, 1997.

9(a). Yoerger, D., Bradley, A., Singh, H., Bachmayer, R., "Surveying a Subsea Lava Flow Using the Autonomous Benthic Explorer (ABE)", *International Journal of Systems Science*, Accepted for publication.

(b) Also translated for publication in Japan by Prof Tamaki Ura.

10. Stewart, W.K., Chu, D., Malik, S., Lerner, S., Singh, H., Quantitative Seafloor Characterization using a Bathymetric Sidescan Sonar, *IEEE Journal of Oceanic Engineering*, vol. 19, no. 4, pp. 599-610, October, 1994.

11. Goff, J., Stewart, W.K., Singh, H., Tang, X. “Quantitative Analysis of Sea Ice Draft. 2. Application of stochastic modeling to intersecting topographic profiles.” *Journal of Geophysical Research*, vol. 100, no C4, April 15, 1995.

## **Publications submitted for review**

1. Singh, H., Stewart, W.K. “An Entropic Framework for Sonar Sensing.” Submitted to the IEEE Journal of Oceanic Engineering.

2. Singh, H., Howland, J., Pizarro, O., Large Area Photomosaicking in the Deep Ocean, Submitted to the IEEE Journal of Oceanic Engineering.

3. Bradley, A., Feezor, M., Singh, H., Power Systems for Autonomous Underwater Vehicles, Submitted to the IEEE Journal of Oceanic Engineering.

## **Refereed Conference Publications**

## Non-reviewed Journals

1. Howland, J., Singh, H., Marra, M., Potter, D., “Digital Mosaicking of Underwater Imagery”, pp. 65-69, Sea Technology, June 1999.
2. ABE imaging for Sea Tech

## Conference Publications

1. Yoerger, D.R., Bradley, A. M., Singh, H., Walden, B., “Mapping the deep seafloor with the Autonomous Benthic Explorer”, submitted to the UUVS 2000 Conference.
2. Howland, J., Singh, H., “Simulation of the Deep Sea Mosaicking Process”, submitted to the 2000 MTS/IEEE Oceans Conference, Providence, RI.
3. Eustice, R., Singh, H., Howland, J., “Image Registration Underwater for Fluid Flow Measurements and Photomosaicking”, submitted to the 2000 MTS/IEEE Oceans Conference, Providence, RI.
4. Roman, C., Pizarro, O., Eustice, R., Singh, H., “ “, submitted to the 2000 MTS/IEEE Oceans Conference, Providence, RI.
5. Singh, H., Roman, C., Whitcomb, L.L., Yoerger, D., Advances in Fusion of High Resolution Underwater Optical and Acoustic Data, pp 206-211, Proceedings of the 2000 International Symposium on Underwater Technology.
6. Yoerger, D., Bradley, A., Singh, H., Walden, B., Cormier, M.H., Ryan, W., Multisensor Mapping of the Deep Seafloor with the Autonomous Benthic Explorer, pp 248-253, Proceedings of the 2000 International Symposium on Underwater Technology.
7. Louis Whitcomb, Dana R. Yoerger, and Hanumant Singh. Combined Doppler/LBL Based Navigation of Underwater Vehicles. In Proceedings of the 11th International Symposium on Unmanned Untethered Submersible Technology, Durham, New Hampshire, USA, August 1999.
8. Singh, H., Weyer, F., Howland, J., Duester, A., Yoerger, D., Bradley, A., “Quantitative Stereo Imaging from the Autonomous Benthic Explorer (ABE)”, *Proceedings of the Oceans '99 MTS/IEEE conference*.
9. Singh, H., Pizarro, O., Whitcomb, L.L., Yoerger, D., In-situ Attitude Calibration for High Resolution Microbathymetric Surveys, submitted to the *2000 International Conference on Robotics and Automation*
10. Whitcomb, L.L., Yoerger, D., Singh, H., Howland, J., Combined doppler/lbl based navigation of underwater vehicles”, *Proceedings of the 11th International Symposium on Unmanned Untethered Submersible Technology*, Durham, New Hampshire, USA August 1999.
11. Whitcomb, L. L., Yoerger, D., Singh, H., Advances in Doppler-Based Navigation of Underwater Robotic Vehicles, *1999 International Conference on Robotics and Automation*, Detroit, 1999.

Resolution Mapping for Deep Water Archaeology, *1998 Annual Meeting of the Society of Historical Archaeology*.

16. Singh, H., Bowen, M., Hover, F., LeBas, P., Yoerger, D., "Intelligent Docking for an Autonomous Ocean Sampling Network", *Oceans97, MTS/IEEE Conference*, Halifax, October 1997.

17. Singh, H., Yoerger, D., Bradley, A., Bachmayer, R., Stewart, W.K. "Sonar Mapping with the Autonomous Benthic Explorer (ABE)", in *Proceedings of the 9th International Symposium on Unmanned Untethered Submersible Technology*, Durham, New Hampshire, September, 1995.

18. Singh, H., Stewart, W.K. "An Entropic Framework for Sensor Modelling", *Oceans 96 MTS/IEEE Conference*, Ft. Lauderdale, Florida, Sept. 23-25, 1996.

19. Singh, H., Freitag, L., Henrichsen, H., Yoerger, D., Catipovic, J. "An Integral Approach to Multiple Vehicle AUV Communications, Navigation and Docking", *Oceans 96 MTS/IEEE Conference*, Ft. Lauderdale, Florida, Sept. 23-25, 1996.

20. Burian, E., Yoerger, D., Bradley, A., Singh, H., "Gradient Search with Autonomous Underwater Vehicles using Scalar Measurements", *1996 Symposium on Autonomous Underwater Vehicle Technology*, Monterey, CA.

21. Yoerger, D., Bradley, A., Singh, H., Bachmayer, R., "Surveying a Subsea Lava Flow Using the Autonomous Benthic Explorer (ABE)", *6th IARP Workshop on Underwater Robotics*, Toulon, France, March 1996.

## **Posters / Abstracts**

1. Cormier, M.-H.; Ryan, W.B.F.; Jin, W.; Shah, A.; Bradley, A.M.; Yoerger, D.R.; Singh, H. Inflationary lava flows fed by a large fissure eruption on the crest of the East Pacific Rise at 17°28'S, *the European Geological Society 2000 meeting*, Nice, France.

2. Ryan, W.B.F., Cormier, M.-H., Bradley, A.M., Yoerger, D.R., Singh, H., Branching and confluence of axially-fed lava channels on the crest of the East Pacific Rise at 17°28'S, *Fall 1999 Meeting of the American Geophysical Union*.

3. Cormier, M.H., Ryan, W.B.F., Jin, W., Shah, A., Bradley, A., Yoerger, D.R., Singh, H., Sinton, J., Batiza, R., Rubin, K., Building of the extrusive crust of the EPR at 17°28'S through fissure-fed inflationary lava flows, *Fall 1999 Meeting of the American Geophysical Union*.

4. Stein, S., Lin, J., Stein, C., Bradley, A., Von Herzen, R., Yoerger, D., Singh, H., "An Autonomous Seafloor Heat Flow Measurement System", *1998 Fall Meeting of the American Geophysical Union*.

5. Yoerger, D., Singh, H., Howland, J., Whitcomb, L., Lerner, S., "High Resolution Optical and Microbathymetric Mapping using the Jason ROV", *1998 Fall Meeting of the American Geophysical Union*.

6. Yoerger, D., Bradley, A., Bachmayer, R., Catanach, R., Duyster, A., Liberatore, S., Singh,

- 1999 Evaluation of doppler based navigation for the DSV Alvin, aboard the *R/V Atlantis*.
  - 1999 The Ashkelon99 Deep Ocean Archaeological Expedition to the Mediterranean using the Jason ROV aboard the *R/V Northern Horizon*
  - 1999 SITE99 Experiment conducted out of the Monterey Bay Aquarium and Research Institute. Demonstrating docking with the Odyssey AUV.
  - 1998 Docking demonstration for Navoceano with the Odyssey AUVs from the *R/V Gyre*.
  - 1998 AOSN/LOOPS cruise in Mass Bay with the Odyssey AUVs from the *R/V Oceanus*.
  - 1998 High Resolution Mapping at a hydrothermal vent area using the Jason ROV from the *R/V Atlantis*.
  - 1998 Labrador Sea AOSN deployment with the Odyssey AUVs from the *R/V Knorr*.
  - 1997 Deep Water Archaeology in the Meditteranean
  - 1997 Docking and power transfer trials in Cape Cod Bay with the Odyssey AUV aboard the *R/v Cape Hatteras, Co-Chief Scientist*.
  - 1997 Docking and power transfer trials in Cape Cod Bay with the Odyssey AUV aboard the *Diane G, Co-Chief Scientist*.
  - 1996 Stereo and Magnetic surveys with ABE and JASON operations in the Juan de Fuca region aboard the *R/V T.G. Thompson*.
  - 1996 Buzzards Bay docking trials with the Odyssey class AUVs aboard the *Diane G*.
  - 1995 Magnetic Surveys in the Juan de Fuca region with ABE and Alvin aboard the *Atlantis*
- II.*
- 1994 Shallow water mapping exercises with the JASON ROV off the WHOI dock.
  - 1993 Jason IV, Guaymas Basin aboard the *DSVSS Laney Chouest*.
  - 1991 Deep Water Dump Site 106, JASON, DSL120 Towed Sonar, *R/V Betty Chouest*.