Mahesh R Panicker, PhD, Senior Member IEEE

CONTACT INFORMATION	Assistant Professor, Electrical Engineering, Indian Institute of Technology - Palakkad, Ahalia Integrated Campus, Kozhippara, Palakkad, Kerala 678557 India

Phone: (91) 4923226422

E-mail: mahesh@iitpkd.ac.in

RESEARCH INTERESTS

Diagnostic Ultrasound Systems, Signal Processing and Imaging, Biomedical Signal Analysis, Medical Internet of Things, Signal Processing for Machine to Machine Communication, Reconfigurable Digital Signal Processing, Digital Front End for Cognitive/Software Defined Radio.

EDUCATION

Doctor of Philosophy (PhD) *July 2005 - July 2008*
School of Computer Engineering, Nanyang Technological University (NTU), Singapore
- Dissertation Topic: "Reconfigurable low complexity digital filter banks for software radio receivers"
- Advisor: Assoc. Prof. A. P. Vinod (NTU, Singapore)

Bachelor of Technology (B.Tech (Hons)) *Nov 1999 - July 2003*
Department of Electrical and Electronics Engineering, Rajiv Gandhi Institute of Technology (Govt. Engineering College), Mahatma Gandhi University, Kerala, India
- Percentage Marks: 88% (First Rank in the University)
- FYP Title: "Microprocessor based Autonomous Robot"
- Advisor: Dr. Dinesh Gopinath , Asst.Professor in Electrical Engineering, College of Engineering, Thiruvananthapuram, Kerala, India.

EMPLOYMENT HISTORY

Samsung Research, Bangalore *May 2017 - Till Now*

Senior Chief Engineer at Ultrasound Systems, Healthcare and Medical Equipments (HME), Samsung Research Institute, Bangalore, India.
Involved in research, development and productization of advanced signal processing, analytics and imaging techniques for diagnostic ultrasound systems.

General Electric (GE) Global Research, Bangalore *Aug 2010 - April 2017*

Lead Engineer at Software Sciences and Analytics Research, GE Global Research, John F Welch Technology Center, Bangalore, India.
Helped in establishing diagnostic ultrasound imaging lab in GE Global Research, Bangalore and in establishing collaboration with General Imaging business, GE Healthcare, Milwaukee. Involved in development of advanced analytics, signal processing algorithms/systems for applications in health care, energy, oil and gas and transportation domains. Filed 10 patents and involved in many of the popular GE products such as diagnostic ultrasound systems, non-invasive neonatal/fetal heart rate monitoring, compressor blade health monitoring (BHM) and Tier4 locomotive prognostics.

Nanyang Technological University (NTU), Singapore *Aug 2008 - July 2010*

Research Fellow at Center for High Performance Embedded Systems (ChiPES), NTU, Singapore. Involved in development of novel reconfigurable low complexity spectrum sensing algorithms and architectures for military and cognitive radios.

SUPELEC, Rennes, France *Nov 2007 - Dec 2007*

Sponsored Internship at SUPELEC in the Signal, Communication et Electronique Embarquee (SCEE) team as part of Merlion Project Grant (Dossier No. 9.03.07), France-Singapore Cooperation Platform in Science and Technology.
Involved in development of novel spectrum sensing architectures for cognitive radio.

Nanyang Technological University (NTU), Singapore   *Aug 2008 - July 2010*

Teaching Assistance at School of Computer Engineering, NTU, Singapore.
Handled sessions in Instrumentation and Data Acquisition Lab and Digital Systems Lab.

Mahatma Gandhi University, Kottayam, Kerala , India   *Aug 2003 - July 2005*

Lecturer at SAINTGITS College of Engineering, MG University, Kerala, India.
Taught basic and advanced courses in Electrical and Electronics Engineering.

HONORS/AWARDS
- Nanyang PhD Scholarship, NTU Singapore.
- Gold medal for topper in B.Tech (EEE), Mahatma Gandhi University, Kerala, India
- 2015 GE Global Research Annual Award for Exemplifying GE Purpose and Innovation
- 2013 GE Technical Excellence Award in Services Technologies
- 2013 GE Customer Site Demonstration Award for Tier4 Locomotive Analytics
- 2012 GE Customer Site Demonstration Award for Compressor Blade Health Monitoring
- 11 GE Technical Expertise Awards - 2011 - 2017

PROFESSIONAL ACTIVITIES
- Senior Member, IEEE
- MATRIZ TRIZ Level 2 Certification (TRIZ Practitioner)
- Member, Technical Committee on Brain-Machine Interface Systems, IEEE Systems, Man and Cybernetics Society
- Member, IEEE Signal Processing Society
- Member, IEEE Communications Society
- Member, IEEE Systems, Man and Cybernetics Society
- Six Sigma Green Belt Certification
- Program Committee, International Symposium on Electronic System Design (ISED), 2011-2014
- Program Committee, International Conference on Eco-friendly Computing and Communication Systems (ICECCS 2013)
- Program Committee, International Conference on Advances in Computing and Communications (ACC 2013)
- Track Chair, IEEE International Conference on Information, Communications and Signal Processing (ICICS 2009).
- Reviewer of IEEE Transactions on Signal Processing, IEEE Transactions on Circuits and Systems - I and II, IEEE Transactions on Vehicular Technology, IEEE Transactions on VLSI Systems, IET Transactions on Signal Processing, Springer Journal of Signal Processing Systems for Signal, Image and Video Technology and International conferences such as ISCAS, ICCS, ICICS, TENCON, SPCOM

RESEARCH GRANTS
Title: Development of a Real Time Spectral Analysis and Filtering System Based on Lyrtech SFF
Role: Co-Investigator with Assoc. Prof. Vinod A Prasad, NTU.
Funding Organization: Temasek Laboratories/DSO National Labs, Defence Science and Technology Agency (DSTA)
Amount: 64000 SGD
Duration: September 2008 - September 2009

PATENTS

1. Method of inspection for corrosion under insulation - Part I- System (Filed Jul 2011).
2. Method of inspection for corrosion under insulation - Part II- Algorithms (Filed Jul 2011).
3. Methods and system to monitor health of rotor blades - Part I
   (http://patents.justia.com/patent/20150184536).
4. Methods and system to monitor health of rotor blades - Part II
   (http://patents.justia.com/patent/20160169765).
5. Methods and systems to determine rotor imbalance - Part I (Filed Dec 2013).
6. Methods and systems to determine rotor imbalance - Part II
   (http://patents.justia.com/patent/20160169765).
7. System and method for monitoring machines
   (http://patents.justia.com/patent/20150369687).
8. Systems and methods for inspecting reinforced concrete structures
   (https://www.google.com/patents/US20150115980)
9. Method and system for measuring a volume of an organ of interest
   (https://patents.google.com/patent/US20180085043A1)
10. System and method for imaging deeper tissues (Filed Feb 2017)

JOURNAL PUBLICATIONS

1. **R. Mahesh** and A. P. Vinod, "An area-efficient non-uniform filter bank for low overhead reconfiguration of multi-standard software radio channelizers," *Journal of Signal Processing Systems for Signal, Image and Video Technology* (formerly the Journal of VLSI Signal Processing Systems for Signal, Image and Video Technology), Springer, vol. 64, no. 3, pp.413-428, Sep. 2011. (Citations: 2)
2. **R. Mahesh** and A. P. Vinod, "A low complexity flexible spectrum sensing scheme for mobile cognitive radio terminals," *IEEE Transactions on Circuits and Systems II*, vol. 58, no. 6, pp.371-375, June 2011. (Citations: 20)
3. **R. Mahesh** and A. P. Vinod, "Low complexity flexible filter banks for uniform and non-uniform channelization in software radios using coefficient decimation," *IET Circuits, Devices and Systems*, vol. 5, no. 3, pp.232-242, May 2011. (Citations: 36)
4. **R. Mahesh** and A. P. Vinod, "A Reconfigurable Low Area Complexity Filter Bank Architecture based on Frequency Response Masking for Non-Uniform Channelization in Software Radio Receivers," *IEEE Transactions on Aerospace and Electronic Systems*, pp. 1241-1255, vol. 47, no. 2, April 2011. (Citations: 35)
5. **R. Mahesh** and A. P. Vinod, "New reconfigurable architectures for implementing FIR filters with low complexity," *IEEE Transactions on Computer-Aided Design of Integrated Circuits and Systems*, vol. 29, no. 2, pp.275-288, Feb. 2010. (Citations: 104)
6. **R. Mahesh**, A. P. Vinod, E. M-K. Lai and Amos Omondi, "Filter bank channelizers for multi-standard software defined radio receivers," *Journal of Signal Processing Systems for Signal, Image and Video Technology*, Springer, Article in Press: DOI 10.1007/s11265-008-0327-y. (Citations: 41)
7. Jimson Mathew, **R. Mahesh**, A. P. Vinod and Edmund M-K. Lai, "Realization of low power high-speed channel filters with stringent adjacent channel attenuation specifications for wireless communication receivers," *IEICE Transactions on Fundamentals of Electronics, Communications and Computer Sciences*, vol. E91-A, no.9, pp. 2564-2570, September 2008. (Citations: 2)
8. **R. Mahesh** and A. P. Vinod, "Reconfigurable frequency response masking filters for software radio channelization," *IEEE Transactions on Circuits and Systems-II*, pp.274-278, vol. 55, no. 3, March 2008. (Citations: 50)
9. **R. Mahesh** and A. P. Vinod, "A new common subexpression elimination algorithm for realizing low complexity higher order digital filters," *IEEE Transactions on Computer-Aided Design of Integrated Circuits and Systems*, pp. 217-229, vol. 27, no. 2, Feb. 2008. (Citations: 98)

CONFERENCE PUBLICATIONS

1. **R. Mahesh**, P. Bhushan, Ek Tsoon Tan, J. Suresh, M. Radhika, M. Luca, M. Rakesh, "Improving neighborhood voxel correlation in resting state fMRI using BOLD signal decomposition ," in Proc. of *OHBM 2016*, Geneva, Switzerland, June 2016. (Citations: 0)

2. P. Bhushan, **R. Mahesh**, Ek Tsoon Tan, J. Suresh, M. Radhika, M. Luca, M. Rakesh, "Spatio-temporal denoising in resting state fMRI," in Proc. of *OHBM 2016*, Geneva, Switzerland, June 2016. (Citations: 0)

3. P. Bhushan, **R. Mahesh**, M. Radhika, J. Suresh, "Group NMF analysis for resting state fMRI," in Proc. of *ISMRM 2016*, Singapore, May 2016. (Citations: 0)

4. **R. Mahesh**, P. Bhushan, Ek Tsoon Tan, J. Suresh, "Blind functional clustering of resting state fMRI using non-negative matrix factorization," in Proc. of *OHBM 2016*, Hawaii, June 2015. (Citations: 0)

5. P. Bhushan, **R. Mahesh**, Ek Tsoon Tan, J. Suresh, "Optimal wavelet basis selection for resting state fMRI analysis," in Proc. of *OHBM 2016*, Hawaii, June 2015. (Citations: 0)

6. Smitha K. G., A. P. Vinod and **R. Mahesh**, "Reconfigurable area and power efficient I-Q mapper for adaptive modulation," in Proc. of *54th IEEE International MidWest Symposium on Circuits and Systems (MWSCAS)*, Seoul, South Korea, August 2011. (Citations: 4)

7. Smitha K. G., **R. Mahesh** and A. P. Vinod, "Challenges in digital filter bank implementation from a cognitive radio perspective - A review," in Proc. of *Asia-Pacific Signal and Information Processing Association (APSIPA) Annual Summit and Conference*, Singapore, December 2010. (Citations: 0)

8. **R. Mahesh** and A. P. Vinod, "Reconfigurable discrete Fourier transform filter banks for variable resolution spectrum sensing," in Proc. of *IEEE International Conference on Communication Systems*, November 2010, Singapore. (Citations: 5)

9. **R. Mahesh** and A. P. Vinod, "Reconfigurable discrete Fourier transform filter banks for multi-standard channelizers," in Proc. of *IEEE International Conference on Signal Processing and Communications*, Bangalore, India, July 2010. (SPCOM 2010). (Citations: 4)

10. S. J. Darak, A. P. Vinod, **R. Mahesh** and E. M-K. Lai "A reconfigurable filter bank for uniform and non-uniform channelization in multi-standard wireless communication receivers," in Proc. of the *17th IEEE International Conference on Telecommunications*, Doha, Qatar, April 2010. (ICT 2010). (Citations: 9)

11. **R. Mahesh**, A. P. Vinod, B. Y. Tan and E. M-K. Lai, "A tree-structured non-uniform filter bank for multistandard wireless receivers," in Proc. of *IEEE International Symposium on Circuits and Systems*, Taiwan, May 2009. (ISCAS 2009). (Citations: 6)

12. S. T. Gul, **R. Mahesh**, C. Moy, A. P. Vinod and Jacques Palicot, "A graphical approach for the optimization of SDR channelizers," in Proc. of *URSI (International Union of Radio Science) General Assembly*, Chicago, USA, August 2008. (Citations: 3)

13. **R. Mahesh** and A. P. Vinod, "Reconfigurable filter banks for software defined radio receivers An alternative low complexity design to conventional DFT filter banks," in Proc. of *URSI (International Union of Radio Science) General Assembly*, Chicago, USA, August 2008. (Citations: 3)

14. **R. Mahesh**, A. P. Vinod, Christophe Moy and Jacques Palicot, "A low complexity reconfigurable filter bank architecture for spectrum sensing in cognitive radios," in Proc. of *3rd International Conference on Cognitive Radio Oriented Wireless Networks and Communications*, Singapore May 2008. (CROWNCOM 2008). (Citations: 29)

15. Smitha K. G., **R. Mahesh** and A. P. Vinod, "A reconfigurable multi-stage frequency response masking filter bank architecture for software defined radio receivers," in Proc. of *IEEE International Symposium on Circuits and Systems*, Seattle, USA, May 2008. (ISCAS 2008). (Citations: 11)

16. **R. Mahesh** and A. P. Vinod, "Coefficient decimation approach for realizing reconfigurable finite impulse response filters," in Proc. of *IEEE International Symposium on Circuits and Systems*, Seattle, USA, May 2008. (ISCAS 2008). (Citations: 71)

17. Jimson Mathew, **R. Mahesh**, A. P. Vinod and E. M-K. Lai, "Realization of low power high-speed channel filters with stringent adjacent channel attenuation specifications for software radio receivers," in Proc. of *Sixth IEEE International Conference on Information, Communications and Signal Processing*, Singapore, December 2007. (ICICS 2007). (Citations: 0)

18. **R. Mahesh** and A. P. Vinod, "A new low complexity reconfigurable filter bank architecture for software radio receivers based on interpolation and masking technique," in Proc. of *Sixth IEEE*

International Conference on Information, Communications and Signal Processing, Singapore, December 2007. (ICICS 2007). (Citations: 3)

19. G. Deepak, **R. Mahesh** and A. Sluzek, "Adaptable area-efficient parallel architecture for grey and color image convolvers," in Proc. of IEEE International Symposium on Signals, Circuits and Systems, 2007, pp. 1-4, Vol. 2, July 2007. (ISSCS 2007). (Citations: 1)

20. **R. Mahesh** and A. P. Vinod, "An architecture for integrating low complexity and reconfigurability for channel filters in software defined radio receivers," in Proc. of *IEEE International Symposium on Circuits and Systems*, pp. 2514- 2517, May 2007, USA. (ISCAS 2007). (Citations: 7)

21. **R. Mahesh** and A. P. Vinod, "Frequency response masking based reconfigurable channel filters for software radio receivers," in Proc. of *IEEE International Symposium on Circuits and Systems*, pp. 2518-2521, May 2007, USA. (ISCAS 2007). (Citations: 14)

22. G. Deepak, **R. Mahesh** and A. Sluzek, "Design of an area-efficient multiplierless processing element for fast two dimensional image convolution," in Proc. of *13th IEEE International Conference on Electronics, Circuits and Systems*, pp.467-470, Dec. 2006 (ICECS 2006). (Citations: 3)

23. **R. Mahesh** and A. P. Vinod, "Reconfigurable low complexity FIR filters for software radio receivers," in Proc of *17th IEEE International Symposium on Personal, Indoor and Mobile radio communications*, pp. 1-5, Finland, Sep. 2006. (PIMRC 2006). (Citations: 22)

24. **R. Mahesh** and A. P. Vinod, "A new common subexpression elimination algorithm for implementing low complexity FIR filters in software defined radio receivers," in Proc. of *IEEE International Symposium on Circuits and Systems*, pp. 4515 4518, Greece, May 2006. (ISCAS 2006). (Citations: 24)

INVITED TALKS   "Compressive Sampling - A Paradigm Shift in Digital Signal Processing", *Workshop on Advances in Signal and Image Processing*, GITAM University, Vishakapatanam, Feb 2014

"Advances in Industrial Digital Signal Processing", *Technical Quality Improvement Program (TQIP) for Faculty on Advances in Digital Systems*, Cochin University of Science and Technology (CUSAT), Kochi, June 2011

"Reconfigurable Low Complexity Digital Filters", *Military Radio Lecture Series*, NTU, Singapore, Feb 2009

"Reconfigurable Low Complexity Spectrum Sensing", *Visitor Lecture Series*, SUPELEC, Rennes, France, Dec 2008

"Reconfigurable Low Complexity Digital Filter Banks for Software Radio Receivers", *Graduate Students Workshop organized by IEEE CAS society*, Singapore, September 2007.

SKILLS
- Programming Languages: *Verilog, C, C++, Assembly Language: 8051 Programming using Reads 51*
- Programming Tools: *Python, MATLAB, Simulink (includes Model Based Development Kit), OpenCV, Visual Studio, Xilinx ISE, Code Composer Studio, Sierra Open AT Application Framework, Mentor Graphics ModelSim*
- Word Processing: *LATEX, MS Office Suite*
- Languages: *Proficient in English, Fluent in Malayalam and Hindi*

PERSONAL
BACKGROUND
Nationality: *Indian*
Date of Birth: *27/02/1982*

RESEARCH CON-**Software based Ultrasound Imaging**
TRIBUTIONS

This project was aimed at novel GPU based beamforming concepts, leveraging the raw RF signals from ultrasound arrays. A novel patient specic beamforming approach has been proposed and patented as part of this work. This also included a novel broadband beamforming approach which could cover the entire frequency spectrum of the ultrasound transducer and an adaptive beamforming approach to improve the image quality particularly at depth and based on tissue types.

Quantitative Ultrasound

This project was aimed at real-time estimation of tissue dependent signal properties such as attenuation, speed of sound etc. A novel method to estimate frequency dependent attenuation has been proposed and patented as part of this work.

Ultrasound VectorFlow Imaging

Vector Flow Imaging enables angle independent estimation of the direction and velocity of blood flow in all directions. This provides non-angle dependent visualization of blood hemodynamics in real time. Novel planewave imaging concepts combined with sub-aperture beamforming have been developed and a prototype system has been demonstrated for the same.

Ultrasound Speckle Reduction

This project was aimed at physics based speckle reduction in ultrasound imaging. A novel method to denoise the signal based on matched filtering of the transmitted pulse has been proposed. As part of this work, different coded excitation schemes have been tried out including chirp based excitation, which has the best time-frequency localization.

System and Analytics for Low Cost Freehand 3D Ultra-sound

The objective of the project was to develop a low cost freehand 3D ultrasound based on GE Healthcare VScan system. Low cost inertial measurement units (IMUs) have been mounted on the 2D ultrasound probes coupled with advanced analytics have been developed for the same. A patent has been filed for the same.

Fetal Heart Rate Monitoring

The objective of the project was to develop non-invasive fetal heart rate monitoring system using conventional adult ECG systems. Blind source separation techniques (independent component analysis) such as SOBI/JADE have been tried out with a success rate of 99 perc. The algorithms have been implemented on TI OMAP board.

Analytics for Tumor Detection using Electrical Properties Tomography

The objective of the project was to characterize tumor tissues using MRI transmit maps. A model based global optimization algorithm has been developed which will reconstruct the permittivity and conductivity distributions from transmit maps. Based on the look up table of permittivities and conductivities of human tissues, a tumor can be distinguished from the healthy tissue.

Neuro Analytics using fMRI

The objective of the project was to blindly identify brain functional networks from resting state fMRI signals. Novel blind source separation techniques have been identied to perform the clustering of functional networks. Time frequency analysis has been done to quantify the dynamics in the functional connectivity.

Inspection and Services Analytics - Advanced Reflectom-etry Techniques

The objective of the project was to develop robust signal processing systems to characterize defects in a co-axial waveguide. Higher resolution spectral estimation techniques such as multiple signal classication (MuSiC) have been used for defect location identication. Time-Frequency transforms

have also been applied to localize the defects accurately. Dynamic Wavelet Fingerprinting Technique which converts a 1D signal to a 2D image for more intuitive understanding of the signal has been tried out. The signal system processing system has been prototyped on an inhouse GE platform.

Locomotive Analytics - Rotating Machinery Imbalance Detection

The objective was to detect imbalance in rotors from speed sensor data. A novel real-time algorithm based on Hilbert transform and Goertzel algorithm has been developed and is part of the electronic control units (ECUs) of latest locomotives from GE transportation. This also included the classication of various types of imbalances using support vector machines (SVM).

Structural Analytics for Concrete Inspection

The objective was to detect the health of concrete rebars. Synthetic aperture radar (SAR) technique has been devised and novel singular value decomposition (SVD) based 2D reconstruction techniques have been applied with good success. Signal processing techniques based on variable splitting and constrained optimization has been applied to reduce noise to a large extent.

Low Complexity Dynamically Recongurable Signal Processing for Cognitive Radios

This project was under the Academic Research Fund Tier-2 grant, Ministry of Education, Singapore supervised by Dr. Vinod A Prasad, Assoc. Prof., School of Computer Engineering, NTU, Singapore. The main results of this project include: Implemented of low complexity and recongurable spectrum sensing algorithms based on filter banks and Implemented spectrum shaping in OFDM based cognitive radios (CRs).

Development of a Real Time Spectral Analysis and Filtering System based on Lyrtech SFF

This was a project funded by DSO National Labs, Singapore and supervised by Dr. See Chong Meng Samson, DSO and Dr. Vinod A Prasad, Assoc. Prof., School of Computer Engineering, NTU, Singapore. The main achievements of this project were: Initiated the triggering of the ADCs for coherent sampling and GPS based time-tagging of the digitalized samples, Implemented filter banks on the onboard FPGA to extract 32 individual channels of 500 kHz from the digitized wideband input signal of 16 MHz, Implemented a user dened threshold detector for each of the extracted channels using the onboard FPGA, The detected data was transferred to PC in real time for post processing, This was done using the model based design kit (MATLAB-XILINX-TI MBDK) on Lyrtech SFF kit.

Recongurable low complexity digital filter banks for software radio receivers

This forms the work during PhD thesis. In the thesis, five methods for implementing recongurable low complexity digital filter banks for a software defined radio (SDR) receiver have been proposed. First, a binary sub expression elimination (BSE) algorithm for reducing the complexity of channel filters was proposed. Second, reconfigurability have been incorporated into the proposed BSE architectures. As the third work, reconfigurable low complexity filter banks based on a frequency response masking (FRM) approach was proposed, which resulted in reduced order prototype filter compared to existing filter banks in literature. Based on FRM, a filter bank that can extract channels, whose bandwidths are related by fractional factors has also been presented. As the fifth work, a filter bank that has absolute control over the location of center frequencies of extracted channels, based on a novel coecient decimation approach was proposed.