

From Prototype Development to Startup: Commercializing an Innovative Indoor Gunshot Detector Device

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Proposal Submitted to Entrepreneurship Research Award 2023

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The objective of the research: From January 2023 to September 2023 in the USA, the total number of deaths due to gun violence is 31,394 – among them, 1,273 are children between the ages of 0 to 17, and the total injury is 27,408. It is estimated that 31% of public mass shootings occur in the USA, although it has only 5% of the world's population. One way to reduce the loss from gun violence is to detect the incident early and notify the police as soon as possible. In my FRF 2022-2023 project, I published an article (URL: <https://www.mdpi.com/2571-5577/6/5/94>) and developed a novel gunshot detector device that automatically detects the indoor gunshot sound and then sends the gunshot location to the nearby police or emergency responder's station within a second using the Internet. The emergency responders also receive smartphone notifications as soon as the shooting happens. However, the gunshot detector hardware prototype was tested only by playing gunshot sounds near it in a lab environment – without testing it with real guns due to safety reasons. Playing recorded gunshot sounds from a speaker does not fully resemble the actual gunshot sound from a real gun. Thus, testing the prototype with real gunshots is required to measure its real-time performance and finetune the deep learning model for practical use. The objectives of this project are: a) Develop a dataset of blank gun sounds; b) Train a deep learning model with the new dataset; c) Develop five more gunshot detector device prototypes and test the system with multiple devices; d) Write a journal article. e) Form a startup for commercialization.

Abstract of the proposed paper: In this project, a new dataset of gunshot sounds from blanks will be developed and a deep learning model will be trained to classify gunshot sounds from non-gunshot sounds. The developed gunshot detector device will be finetuned and tested with blank guns.

Significance of the proposed study: The United States sees the most school shootings in the world. Shootings inside other indoor places such as in homes, shopping malls, clubs, places of

worship, etc. are also becoming widespread around the world. The proposed device can be attached to the walls or ceilings of these places – similar to smoke detectors – and they can notify the police as soon as a gunshot is fired. The proposed system will help to stop the shooter early and the injured people can be taken to the hospital quickly – thus more lives can be saved.

Contribution to the literature/its contribution to entrepreneurship practice: Some cities utilize companies such as SoundThinking to detect and localize gunshots on a large scale. In this system, sensor modules are installed around the city at outdoor places and it is not used for indoor crimes. Moreover, these systems are extremely expensive to run and maintain – costing up to 90,000 USD per square mile of coverage per year. This system is installed by the city authority and not by individuals or institutions for personal use. Compared with this work, we plan to form a startup and commercialize the proposed product with a lower price, easier installation, and better performance. Two potential co-founders from Michigan have already shown interest and we had several meetings. I have submitted an Invention Disclosure form to the Technology Transfer Office at EMU for patent application. Based on the proposed work, a journal article will also be published.

Outline of the proposed methodology and timeline for completion

Record blank gun sounds in a soundproof chamber	December 2023
Train the deep learning model with the new dataset	January and February 2024
Test and finetune the gunshot detector device	March and April 2024
Write journal article	May and June 2024
Preparation for startup formation	July and August 2024

Curriculum Vita

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School of Engineering,
Eastern Michigan University,
111U Sill Hall, Ypsilanti, MI 48197.
United States.

ACADEMIC APPOINTMENTS

Sep 2022 – Present **Associate Professor**, Eastern Michigan University, United States.
Aug 2017 – Aug 2022 **Assistant Professor**, Eastern Michigan University, United States.
Aug 2015 – May 2017 **Fixed-Term Faculty**, Central Michigan University, United States.
Aug 2014 – May 2015 **Visiting Assistant Professor**, Miami University, United States.
Jan 2014 – July 2014 **Postdoctoral Fellow (PDF)**, University of Saskatchewan, Canada.

EDUCATION

Sep 2009 – Nov 2013

Doctor of Philosophy (Ph.D.)

Department of Electrical and Computer Engineering, University of Saskatchewan, Canada.

Thesis: *Capsule endoscopy system with novel imaging algorithms*

Sep 2005 – Sep 2007

Masters in Applied Science (M.A.Sc.)

Department of Electrical and Computer Engineering, Concordia University, Canada.

Thesis: *Automatic generation of transactors between RTL and TLM models in SystemC*

Jan 2000 – Oct 2003

Bachelor of Science (B.Sc.), 1st Class Honors,

Department of Electrical and Electronics Engineering, Islamic University of Technology (IUT),
Bangladesh.

Final year project: *Microcontroller based prayer time displayer*

PATENT GRANTED

- Apparatus, methods and systems for randomly accessing pixel data from streaming image sensor data, inventors: **T. H. Khan** and K. Wahid, *US patent no: 8,953,070*, issued on Feb 10th, 2015.
- Methods and apparatus for image processing in wireless capsule endoscopy, inventors: **T. H. Khan** and K. Wahid, *US patent no: 9,088,716*, issued on Jul 21, 2015.

RESEARCH EXPERIENCE

Sep 2022 – Present

Associate Professor, School of Engineering, Eastern Michigan University, United States.

Projects:

- Towards an automatic gunshot detection and notification system using deep learning.
- A smart fire detector with extinguisher class recommendation using deep learning.

Aug 2017 – Aug 2022

Assistant Professor, School of Engineering, Eastern Michigan University, United States.

Projects:

- Early wildfire detection and notification using IoT.
- A smart baby monitor with automatic sleeping posture detection using deep learning.
- IoT connected physical mailbox interfaced with smart devices.
- Automatic snoring detection using deep learning and prevention using a smart wearable gadget.
- Internet of Things connected smart canister system creating automatic shopping list.
- A noninvasive wearable gadget for diaper moisture detection, classification, and notification
- Cloud-based architecture of a smart expiry system with IoT device.
- A smart autonomous microwave oven with food image classification and temperature recommendation learning algorithm.

May 2015 – May 2017

Fixed-Term Faculty,

School of Engineering and Technology, Central Michigan University, United States.

Projects:

- A wearable gadget for automatic diaper moisture detection and notification.
- A cloud based smart-expiry system using QR code.

Aug 2014 – May 2015

Visiting Assistant Professor,

Dept. of Electrical and Computer Engineering, Miami University, United States.

Project: Design of a smart diaper for automatic moisture and motion monitoring.

Jan 2014 – July 2014

Postdoctoral Fellow (PDF),

Dept. of Electrical and Computer Engineering, University of Saskatchewan, Canada.

Projects:

- Exploring multispectral imaging and enhancement algorithms for endoscopic images.
- Wireless body area network (WBAN) and health monitoring.

Sep 2009 – Dec 2013

Research Assistant, Doctoral level

Dept. of Electrical and Computer Engineering, University of Saskatchewan, Canada.

Projects:

- Designing image compression algorithms for capsule endoscopy.
- Application specific integrated circuit (ASIC) chip design, fabrication and testing of the image compressor in CMOS 0.18 μ m technology.
- Miniature field programmable gate array (FPGA) based endoscopy capsule prototype design (hardware design and VHDL coding).
- Microcontroller based data logger design (hardware and firmware).
- Windows based PC software design for image decoding and viewing.
- Animal testing (in-vivo and ex-vivo) of the developed capsule endoscopy system.
- Designing bridge architecture for interfacing high-speed image sensors in embedded systems and its verification in FPGA.
- Enabling satellite communication with Android smart phone for global text messaging.

May 2006 – Sep 2007

Research Assistant, Master's level

Dept. of Electrical and Computer Engineering, Concordia University, Canada.

Project: Design of a SystemC transactor generator tool from AsmL specification and from graphical finite state machine.

INDUSTRIAL EXPERIENCE

Oct 2007 – Jul 2009

System Manager, Embedded System Research Group,

Institute of Information and Communication Technology (IICT), Bangladesh University of Engineering and Technology (BUET), Bangladesh.

Projects:

- Design and development of remote metering system.
- Development of prepaid 3 phase electrical energy meter calibration and testing units.
- Design and development of smart card based prepaid gas metering system.
- Development of global positioning system (GPS) based vehicle tracking system.
- Design and development of prepaid electricity meter testing bench.

Oct 2004 – Aug 2005

Software Engineer, Pre-paid Electrical Energy Meter Project,

Institute of Information and Communication Technology (IICT), BUET, Bangladesh.

Responsibilities include hardware design and microcontroller programming for meter testing tools.

PUBLICATIONS

Books and Chapters

2022

- **T. H. Khan**, *Creating a Smart Home with Deep Learning and Internet of Things*, Eliva Press, 117 pages, 2022. ISBN: 978-9994982875.

2019

- **T. H. Khan**, *Inventions towards Smart Home and Internet of Things*, LAP LAMBERT Academic Publishing, 112 pages, 2019. ISBN: 978-3-330-09103-0.

2014

- **T. H. Khan**, *Capsule Endoscopy System with Novel Imaging Algorithms*, Scholars' Press, 2014. ISBN: 978-3-639-66818-6. [Doctoral thesis reprint].

2013

- **T. H. Khan** and K. Wahid, "Low-cost VLSI architecture for random block-based access of pixels in modern image sensors", in *Embedded Systems: Hardware, Design, and Implementation*, 1st edition, John Wiley & Sons, Inc, 2013, ch. 4, pp. 107-126, 2012. ISBN: 978-1-1183-5215-1.

2003 – 2012

- **T. H. Khan**, *Transactors in SystemC*, Lambert Academic Publishing (LAP), Germany, 2010. ISBN: 978-3-8383-3195-9. [Master's thesis reprint].

Peer reviewed journals

[Q#] indicates SJR Quartiles

2023

- **T. H. Khan**, "Towards an Indoor Gunshot Detection and Notification System Using Deep Learning," *Applied System Innovation*, vol. 6, no. 5, article. 94, ISSN 2571-5577, 2023.

- **T. H. Khan**, "Ultra-Low-Power Architecture for the Detection and Notification of Wildfires Using the Internet of Things," *Internet of Things (IoT)*, vol. 4, issue. 1, pp. 1 – 26, ISSN 2624-831X, 2023.
- 2022
- **T. H. Khan**, "Towards a Low-Cost Object Collecting and Organizing Household Robot using Deep Learning," *European Journal of Electrical Engineering and Computer Science (EJECE)*, vol. 6, issue. 6, pp. 16 – 25, ISSN 2736-5751, 2022.
- 2021
- **T. H. Khan**, "An intelligent baby monitor with automatic sleeping posture detection and notification," *Artificial Intelligence (AI)*, vol. 2, issue. 2, pp. 290 – 306, ISSN 2673-2688, 2021.
 - **T. H. Khan**, "Expiry date digit recognition using convolutional neural network," *European Journal of Electrical Engineering & Computer Science (EJECE)*, vol. 5, issue. 1, pp. 85 – 88, ISSN 2736-5751, 2021.
- 2020
- **T. H. Khan**, "A solar-powered IoT connected physical mailbox interfaced with smart devices," *Internet of Things (IoT)*, vol. 1, issue. 1, pp. 128 – 144, ISSN 2624-831X, 2020.
 - M. R. Hyder and **T. H. Khan**, "Automatic expiry date notification system interfaced with smart speaker," *International Journal of Engineering Science Invention (IJESI)*, ISSN: 2319-6734, vol. 9, issue. 7, pp. 14 – 20, 2020.
 - J. Quinones, A. Lofton and **T. H. Khan**, "A smart door with web controllable door motion and window transparency," *International Journal of Engineering Science Invention (IJESI)*, ISSN: 2319-6734, vol. 9, issue. 6, pp. 6 – 12, 2020.
 - K. Oliver, M. Herter, and **T. H. Khan**, "An architecture of a touchscreen operated window blinds for smart home," *International Journal of Engineering Science Invention (IJESI)*, ISSN: 2319-6734, vol. 9, issue. 5, pp. 34 – 39, 2020.
 - **T. H. Khan**, "An intelligent microwave oven with thermal imaging and temperature recommendation using deep learning," *Applied System Innovation.*, vol. 3, no. 1, article. 3, ISSN 2571-5577, 2020.
- 2019
- **T. H. Khan**, "A deep learning model for snoring detection and vibration notification using a smart wearable gadget," *Electronics*, vol. 8, no. 9, article. 987, ISSN 2079-9292, 2019. [Q2]
 - **T. H. Khan**, "A low power IoT-connected smart canister system creating automatic shopping list," *Journal of Sensor and Actuator Networks (JSAN)*, ISSN 2224-2708, vol. 8, no. 3, article. 38, 2019. [Q2]
 - **T. H. Khan**, "A noninvasive smart wearable for diaper moisture quantification and notification", *International Journal of Electrical and Computer Engineering (IJECE)*, ISSN: 2088-8708, vol. 9, no. 4, part II, pp. 2848-2862, 2019. [Q2].
- 2018
- **T. H. Khan**, "Smart microwave oven with image classification and temperature recommendation algorithm", *International Journal of Electrical and Computer Engineering (IJECE)*, ISSN: 2088-8708, vol. 8, no. 6, part I, pp. 4239-4252, 2018. [Q2].
 - **T. H. Khan**, "Low complexity fluctuation measurement in image processing considering order", *International Journal of Electrical and Computer Engineering (IJECE)*, ISSN: 2088-8708, vol. 8, no. 6, part I, pp. 4253-4257, 2018. [Q2].
 - **T. H. Khan**, "Design of an autonomous smart shower with sensors and actuators", *International Journal of Embedded Systems and Applications (IJESA)*, ISSN: 1839-5171, vol. 8, no. 1/2/3, 18 pages, 2018.

- **T. H. Khan**, "Cloud-based architecture of a smart expiry system with IoT device", *International Journal of Advance Engineering and Research Development (IJAERD)*, ISSN: 2348-6406, vol. 5, no. 4, pp. 641-650, 2018. Impact Factor: 5.71.

2016

- **T. H. Khan**, S. K. Mohammed, M. S. Imtiaz and K. Wahid, "Efficient color reproduction algorithm for endoscopic images based on dynamic color map", *Journal of Medical and Biological Engineering, Springer*, ISSN: 1609-0985, pp. 1-10, 2016. [Q3].
- **T. H. Khan**, S. K. Mohammed, M. S. Imtiaz and K. Wahid, "Color reproduction and processing algorithm based on real-time mapping for endoscopic images," *Springerplus*, vol. 5, no. 17, 16 pages, 2016. [Q1]

2015

- **T. H. Khan**, R. Shrestha, M. S. Imtiaz, and K. Wahid, "Color-reproduction algorithm for transmitting variable video frames and its application to capsule endoscopy," *IET Healthcare Technology Letters*, ISSN: 2053-3713, doi:10.1049/htl.2014.0086, 2015.

2014

- **T. H. Khan**, R. Shrestha, K. Wahid, and P. Babyn, "Design of a smart-device and FPGA based wireless capsule endoscopic system," *Sensors and Actuators A: Physical, Elsevier*, ISSN: 09244247, vol. 221, pp. 77 – 87, 2014. [Q1].
- **T. H. Khan** and K. Wahid, "Design of a lossless image compression system for video capsule endoscopy and its performance in *in-vivo* trials," *Sensors*, ISSN: 1424-8220, vol. 14, issue. 11, pp. 20779 - 20799, 2014. [Q2].
- **T. H. Khan**, R. Shrestha and K. Wahid, "A modular and programmable development platform for capsule endoscopy system," *Journal of Medical Systems, Springer*, ISSN: 0148-5598, vol. 38, issue. 6, article. 57, 2014. [Q2].
- **T. H. Khan** and K. Wahid, "White and narrow band image compressor based on a new color space for capsule endoscopy," *Image Communication, Elsevier*, ISSN: 0923-5965, vol. 29, no. 3, pp. 345 - 360, 2014. [Q2].
- **T. H. Khan** and K. Wahid, "A portable wireless body sensor data logger and its application in video capsule endoscopy," *Microprocessors and Microsystems, Elsevier*, ISSN: 0141-9331, vol. 38, no. 1, pp. 42 - 52, 2014. [Q3].

2012

- **T. H. Khan** and K. Wahid, "An advanced physiological data logger for medical imaging applications," *EURASIP Journal on Embedded Systems, Springer*, ISSN: 1687-3963, 2012:10, doi:10.1186/1687-3963-2012-10, 2012. [Q4].

2011

- **T. H. Khan** and K. Wahid, "Low complexity color-space for capsule endoscopy image compression," *IET Electronics Letters*, ISSN: 0013-5194, vol. 47, no. 22, pp. 1217-1218, doi: 10.1049/el.2011.2211, 2011. [Q2].
- **T. H. Khan** and K. Wahid, "Low power and low complexity compressor for video capsule endoscopy," *IEEE Transactions on Circuits and Systems for Video Technology*, ISSN: 1051-8215, vol. 21, no. 10, pp. 1534-1546, doi: 10.1109/TCSVT.2011.2163985, 2011. [Q1].
- **T. H. Khan** and K. Wahid, "Subsample-based image compression for capsule endoscopy," *Journal of Real-time Image Processing, Springer*, ISSN: 1861-8200, doi: 10.1007/s11554-011-0208-7, 2011. [Q3].
- **T. H. Khan** and K. Wahid, "Lossless and low power image compressor for wireless capsule endoscopy," *VLSI Design, Hindawi Publishing Corporation*, vol. 2011, Article ID 343787, New York, USA, 2011. [Q4].

- **T. H. Khan** and K. Wahid, "Universal bridge interface for DVP-compatible image sensors," *Microprocessors and Microsystems, Elsevier*, ISSN: 0141-9331, vol. 35, issue. 6, pp. 547-556, 2011. [Q3].
- **T. H. Khan** and K. Wahid, "A DVP-based bridge architecture to randomly access pixels of high speed image sensors," *EURASIP Journal on Embedded Systems, Hindawi Publishing Corporation*, vol. 2011, Article ID 270908, New York, USA, 2011. [Q4]

2003 - 2010

- **T. H. Khan** and N.A. Ninad. "Design of a low cost 8051 architecture based microcontroller learning kit," *Asian Journal of Information Technology*, ISSN: 19935994, vol. 5, no. 2, pp. 213-218, 2006. [Q4]

Publications in conference proceedings

2019

- **T. H. Khan**, "Expiry date digits recognition using deep learning," *IEEE National Aerospace & Electronics Conference (NAECON 2019)*, pp. 302-304., Dayton, Ohio, USA, July 2019.

2018

- **T. H. Khan**, "A Wi-Fi based architecture of a smart home controlled by smartphone and wall display IoT device," *First International Virtual Conference on Multidisciplinary Research (IVCMR 2018)*, vol. 3, Issue. 6, pp. 180-184, Walnut, CA, USA, November 2018.
- **T. H. Khan**, "A cloud-based smart expiry system using QR code," *IEEE International Conference on Electro information Technology (EIT 2018)*, pp. 245 – 248, Rochester, Michigan, USA, May 2018.
- **T. H. Khan**, "A smart wearable gadget for noninvasive detection and notification of diaper moisture," *IEEE International Conference on Electro information Technology (EIT 2018)*, pp. 240-244, Rochester, Michigan, USA, May 2018.
- **T. H. Khan**, "An efficient fluctuation measurement method in image processing considering order," *IEEE International Conference on Electro information Technology (EIT 2018)*, pp. 249 - 251, Rochester, Michigan, USA, May 2018.
- **T. H. Khan**, "Towards an autonomous temperature feedback microwave oven with thermal imaging," *IEEE International Conference on Electro information Technology (EIT 2018)*, pp. 444 - 448 Rochester, Michigan, USA, May 2018.

2017

- J. Turner, C. Zellner, **T. H. Khan**, and K. Yelamarthi, "Continuous heart rate monitoring using smartphone," *IEEE International Conference on Electro information Technology (EIT 2017)*, pp. 324-326, Lincoln, Nebraska, USA, May 2017.
- M. Trent, C. Alkevicius, C. Gargarello, **T. H. Khan**, and K. Yelamarthi, "Internet-enabled house pipe temperature monitoring system," *IEEE International Conference on Electro information Technology (EIT 2017)*, pp. 314-316, Lincoln, Nebraska, USA, May 2017.
- K. Laubhan, K. Eggenberger, **T. H. Khan**, and K. Yelamarthi, "Design of a smartphone operated powerstrip," *IEEE International Conference on Electro information Technology (EIT 2017)*, pp. 317-320, Lincoln, Nebraska, USA, May 2017.
- M. Lake, J. Wernette, **T. H. Khan**, and A. Abdelgawad, "Design of a Structural Health Monitoring and Notification System," *IEEE International Conference on Electro information Technology (EIT 2017)*, pp. 321-323, Lincoln, Nebraska, USA, May 2017.

2014

- A. Mostafa, **T. H. Khan**, and K. Wahid, "An improved YEF-DCT based compression algorithm for video capsule endoscopy," *In Proc. International Conference of the IEEE Engineering in Medicine and Biology Society (EMBC'14)*, pp. 2452 – 2456, Chicago, IL, USA, August 2014.

- A. Mostafa, **T. H. Khan**, and K. Wahid, "A low-cost image compression algorithm for wireless endoscopy using YEF color space," *In Proc. Canadian Medical and Biological Engineering Conference – 2014 (CMBEC37)*, Vancouver, BC, Canada, May 2014.
- R. Shrestha, **T. H. Khan**, and K. Wahid, "Towards real-time remote diagnostics of capsule endoscopic images using Wi-Fi," *Middle East Conference on Biomedical Engineering (MECBME 2014)*, pp. 293 – 296, Doha, Qatar, February 2014.

2013

- R. Shrestha, **T. H. Khan**, and K. Wahid, "A Wi-Fi adapter for medical data and imaging applications," *In Proc. International Conference on Energy Aware Computing Systems & Applications (ICEAC 2013)*, pp. 61 - 64, Istanbul, Turkey, December 2013.
- M. S. Imtiaz, **T. H. Khan**, K. Wahid, "New color image enhancement method for endoscopic images," *in Proc. International Conference on Advances in Electrical Engineering (ICAEE)*, pp. 263 - 266, Dhaka, Bangladesh, December 2013.

2012

- A. Mostafa, **T. H. Khan**, K. Wahid, and S. B. Ko, "Efficient color space-based compression scheme for endoscopic images," *In Proc. International Conference on Information Sciences, Signal Processing and their Applications (ISSPA)*, pp. 83 - 86, Montreal, QC, Canada, July 2012.
- **T. H. Khan** and K. Wahid, "Implantable narrow band image compressor for capsule endoscopy," *In Proc. IEEE International Symposium on Circuits and Systems (ISCAS)*, pp. 2203 - 2206, Seoul, Korea, May 2012.

2011

- **T. H. Khan** and K. Wahid, "Design of a DVP compatible bridge to randomly access pixels of high speed image sensors," *In Proc. IEEE International Conference on Consumer Electronics (ICCE)*, pp. 911-912, Las Vegas, USA, January 2011.

2010

- **T. H. Khan**, G. M. Shahabuddin, and K. Wahid, "Design of a bridge to randomly access high speed image sensor pixels in embedded systems," *In Proc. International Conference on Electrical & Computer Engineering (ICECE)*, pp. 450-453, Dhaka, Bangladesh, December 2010.
- **T. H. Khan** and K. Wahid, "Towards design of a bridge to enable high speed image sensors for random access," *In Proc IEEE International Conference on Microelectronics (ICM)*, pp. 431-434, Cairo, Egypt, December 2010.
- **T. H. Khan**, S.M.L. Kabir, S. Hussain, and K. Wahid, "Design and implementation of a low cost electricity meter testing bench," *In Proc. IEEE Symposium on Industrial Electronics and Applications (ISIEA)*, pp. 34-39, Penang, Malaysia, October 2010.

2009

- **T. H. Khan**, T. K. Paul, G. M. Shahabuddin, K. Wahid, A. H. Chowdhury, and S. M. L. Kabir, "Towards design of a smart prepaid gas metering system," *In Proc. IEEE International Conference on Innovation in Information Technology*, pp. 55-59, UAE, December 2009.
- Md. W. Rahman, Md. T. Ahmed, **T. H. Khan** and S. M. L. Kabir, "Design of an intelligent SMS based remote metering system," *In Proc. IEEE International Conference on Information and Automation (ICIA)*, pp. 1040-1043, Zhuhai/Macau, China, 2009.

2007

- **T. H. Khan**, A. Habibi, S. Tahar and O. A. Mohamed, "Automatic generation of SystemC transactors from graphical FSM," *In Proc. IEEE International Conference on Microelectronics (ICM)*, pp. 257-260, Cairo, Egypt, December 2007.

- **T. H. Khan**, A. Habibi, S. Tahar and O. A. Mohamed, "Automatic generation of SystemC transactors from AsmL specification," In *Proc. Forum on specification & Design Languages (FDL'07)*, Barcelona, Spain, September 2007.

2003 – 2006

- **T. H. Khan**, N. A. Ninad, "Low cost EPROM programmer," In *Proc. International Conference on Computer and Information Technology (ICCIT'05)*, Gajipur, Bangladesh, December 2005.
- **T. H. Khan**, N. A. Ninad, "8051 architecture microcontroller learning kit," In *Proc. International Conference on Computer and Information Technology (ICCIT'05)*, Gajipur, Bangladesh, December 2005.
- A. S. Khan, MD. M. Alam, M. Monowar, F. Rabbi, S. Ahmed and **T. H. Khan**, "12 segment display for Bengali numerical characters", In *Proc. National Conference on Computer Processing of Bangla (NCCPB)*, pp. 82 -88, Gajipur, Bangladesh, 2004.

PRESENTATIONS

Jul 2019	Expiry date digits recognition using deep learning, IEEE National Aerospace & Electronics Conference (NAECON 2019), Fairborn, Ohio, USA.
Nov 2018	A Wi-Fi based Architecture of a Smart Home Controlled by Smartphone and Wall Display IoT Device, First International Virtual Conference on Multidisciplinary Research (IVCMR 2018), Walnut, CA, USA. [Online presentation]
May 2018	An efficient fluctuation measurement method in image processing considering order, IEEE international conference on Electro information technology (EIT 2018), Rochester, Michigan, USA.
May 2018	A cloud-based smart expiry system using QR code, IEEE international conference on Electro information technology (EIT 2018), Rochester, Michigan, USA.
May 2018	A smart wearable gadget for noninvasive detection and notification of diaper moisture, IEEE international conference on Electro information technology (EIT 2018), Rochester, Michigan, USA.
May 2018	Towards an autonomous temperature feedback microwave oven with thermal imaging, IEEE international conference on Electro information technology (EIT 2018), Rochester, Michigan, USA.
Oct 2013	A Modular and Programmable Capsule Endoscopy System, CMC TEXPO Symposium 2013, Gatineau, Quebec, Canada.
Jun 2013	Low complexity color-space for capsule endoscopy image compression, Pandit Deendayal Petroleum University (PDPU) exposure program, University of Saskatchewan, Canada.
Apr 2013	Low complexity color-space for capsule endoscopy image compression, IEEE North Saskatchewan Graduate Research Symposium, University of Saskatchewan, Canada.
Apr 2011	A low complexity image compressor for wireless capsule endoscopy, IEEE North Saskatchewan Graduate Research Symposium, University of Saskatchewan, Canada.
Dec 2010	Design of a DVP compatible bridge to randomly access pixels of high speed image sensors, IEEE International Conference on Consumer Electronics (ICCE), Las Vegas, USA. [Web-based Presentation].
Mar 2010	Design of a novel bridge to interface high speed image sensors in embedded system, TJU - UofS Workshop, University of Saskatchewan, Canada.

GRANTS AND AWARDS

- A smart fire detector with extinguisher class recommendation using deep learning, Role: Primary Investigator, *Summer Research/ Creative Activity Award (SRA)*, Eastern Michigan University, 2023, Amount: 12,000 USD. Approved on Jan 16, 2023.
- Towards an automatic gunshot detection and notification system using deep learning, Role: Primary Investigator, *Faculty Research Fellowship (FRF)*, Eastern Michigan University, 2022, Amount: 1,854 USD and 100% course release for Winter 2023. Approved on Mar 15, 2021.
- An Internet of Things based Sensor Network for Early Wildfire Detection and Notification, Role: Primary Investigator, *Provost's Research Support Award (RSA)*, Eastern Michigan University, 2021, Amount: 1,000 USD. Approved on Dec 6, 2021.
- Early Wildfire Detection and Notification using the Internet of Things, Role: Primary Investigator, *Summer Research/ Creative Activity Award (SRA)*, Eastern Michigan University, 2021, Amount: 12,000 USD. Approved on Jan 15, 2021.
- A smart baby monitor with automatic sleeping posture detection and notification, Role: Primary Investigator, *Faculty Research Fellowship (FRF)*, Eastern Michigan University, 2020, Amount: 2,999 USD and 100% course release for Winter 2021. Approved on Mar 31, 2020.
- Internet of Things Connected Smart Mailbox with Automatic Delivery Notification, Role: Primary Investigator, *GameAbove Faculty First Funding*, Eastern Michigan University, 2020, Amount: 4,825 USD. Approved on Jan 10, 2020.
- IUSE: EHR Collaborative Research: A Development of Collaborative Interdisciplinary Curriculum Programs to Improve Undergraduate STEM Education, Role: T. H. Khan (Co-PI), *National Science Foundation (NSF)*, *Improving Undergraduate STEM Education: Education and Human Resources*, 2020, Requested amount: 299,862 USD. (Submitted: Feb 3, 2020; Status: Declined).
- CyberTraining: Implementation: Medium: A Collaborative Cyberinfrastructure Development for Comprehensive Security Training, Role: T. H. Khan (Co-PI), *National Science Foundation (NSF)*, *Training-based Workforce Development for Advanced Cyberinfrastructure (CyberTraining)*, 2020, Requested amount: 250,001 USD. (Submitted: Jan 15, 2020; Status: Declined).
- Automatic snoring detection and prevention using a smart wearable gadget, Role: Primary Investigator, *Summer Research/ Creative Activity Award (SRA)*, Eastern Michigan University, 2019, Amount: 12,000 USD. Approved on Jan 15, 2019.
- SCH: INT: RUI: A Smart Wearable Gadget for Autonomous Sensing, Quantification and Notification of Diaper Moisture, Roles: T. H. Khan (PI), D. Snyder (Co-PI from Chemistry), and D. Laurin-Phelan (Co-PI from Early Childhood Education); *National Science Foundation (NSF)*, *Smart and Connected Health (SCH) program*, 2018. Requested Amount: \$121,310. (Submitted: Dec 11, 2018; Status: Declined).
- Internet of Things Connected Smart Canister System Creating Automatic Shopping List, *James H. Brickley Endowment for Faculty Professional Development and Innovation*, Eastern Michigan University, 2018, Value: 1,957 USD for SS&M. Approved on Oct 15, 2018.
- A smart autonomous microwave oven with food image classification and temperature recommendation learning algorithm, Role: Primary Investigator, *Faculty Research Fellowship (FRF)*, Eastern Michigan University, 2018, Amount: 3,000 USD with 75% course release. Approved on Mar 29, 2018.
- A noninvasive wearable gadget for diaper moisture detection, classification, and Notification, Role: Primary Investigator, *Summer Research/ Creative Activity Award (SRA)*, Eastern Michigan University, 2018, Amount: 12,000 USD. Approved on Jan 12, 2018.

- A cloud based smart-expiry system using QR code, Role: Primary Investigator, *James H. Brickley Endowment for Faculty Professional Development and Innovation, Eastern Michigan University*, 2017, Amount: 998.00 USD. *Approved on Oct 16, 2017.*
- A wearable gadget for noninvasive detection, classification, and notification of diaper moisture, *Office of Research Development and Administration (ORDA) Culture of Research Excellence (CoRE) Grant Writing Program award, Eastern Michigan University*, 2017, Role: Primary Investigator, Value: 2-course releases in Winter 2018 and Fall 2018. *Approved on Nov 1, 2017.*
- A wearable gadget for automatic diaper moisture detection and notification, Role: Primary Investigator, *Faculty Research and Creative Endeavors (FRCE), Central Michigan University*, 2015 – 2016, Amount: 3,482 USD. *Approved on Oct 20, 2015 (grant #48147).*
- Noninvasive Detection, Notification, and Classification of Diaper Moisture using a Wearable Gadget, Role: Primary Investigator, *National Science Foundation (NSF), Smart and Connected Health (SCH) program*, 2016, Amount: 223,480 USD. *(declined)*
- Automatic diaper moisture detection and notification using a wearable gadget, Role: Primary Investigator, *Procter and Gamble*, 2015 – 2016, Amount: 9,975 USD. *(declined)*.

RESEARCH INTEREST

- Internet of Things (IoT).
- Cyber-physical systems (CPS).
- Artificial Intelligence (AI), Machine Learning (ML), and Deep learning (DL).
- Reconfigurable computing and prototyping of FPGA and microcontroller based embedded systems.
- Image processing.
- Smart home.

TEACHING EXPERIENCE

Aug 2017 – Present

School of Engineering, Eastern Michigan University, United States.

Responsibilities:

- Lecturing undergraduate classes on microcontrollers (EECE 351), digital system design with HDL (EECE 352), advanced digital system design with FPGA (EECE 452), computer interfacing programming (CET 384), sensor, control and data acquisition (CET 374), computer hardware and software (CET 215), introduction to computing in engineering technology (CET 151), engineering graphics (CET 120), engineering database development (CET 351) courses, web development for engineering application (CET 353).
- Preparing and instructing lab sessions.
- Preparing assignments, quizzes and exams.

Aug 2015 – May 2017

Fixed-Term Faculty,

School of Engineering and Technology, Central Michigan University, United States.

Responsibilities:

- Lecturing undergraduate classes on embedded system (EGR 481), VLSI design (EGR 487), applied circuits (IET 291), computer circuit simulation (EGR 394), microelectronics and computer lab (EGR 398), signals & system theory (EGR 391), and introduction to

engineering (EGR 120), computer system design using HDL (EGR 390), communication systems (EGR 496) courses.

- Preparing and instructing lab sessions.
- Preparing and grading quizzes and exams.
- Supervision of course projects.

Aug 2014 – May 2015

Visiting Assistant Professor,

Department of Electrical and Computer Engineering, Miami University, United States.

Responsibilities:

- Lecturing undergraduate classes on embedded system (ECE 387) and circuit analysis (ECE 205) courses.
- Instructing lab sessions.
- Grading exam papers.
- Supervision of senior design project (ECE 448/449).

Sep 2012 – Sep 2013

Teaching Assistant,

Department of Electrical and Computer Engineering, University of Saskatchewan, Canada.

Responsibilities:

- Laboratory supervision and grading lab reports on Microprocessors, embedded operating systems and AM/Sampling lab (EE/CME 392), verification of digital systems (CME 435).
- Designed rubric for grading lab performances and notebooks.
- Prepared lab experiments and solutions for ARM microcontroller.
- Supervision experience of summer intern students on the following projects:
 - Localization of endoscopy capsule
 - Design of Nordic RF transceiver to Bluetooth converter
 - Endoscopy image acquisition in Android Smartphone by Bluetooth

TEACHING INTEREST

- Embedded Systems Design
- Internet of Things
- Web and database development
- Deep Learning
- Digital Systems Design with HDL and FPGA
- VLSI design
- Programming with C/C++
- Circuit Analysis

PROFESSIONAL DEVELOPMENT WORKSHOPS AND COURSES

Fall 2011 Completed the course “*Instructional Skills for Graduate Students,*” offered by the *Gwenna Moss Centre for Teaching Effectiveness of University of Saskatchewan.*

The course covered:

- Teaching roles and responsibilities.
- Lesson planning.

- Teaching and learning styles and strategies.
 - Assessment and evaluation.
- Aug 2015 Attended workshop on “*High-Impact Syllabus Development & Design*” offered by Center for Excellence in Teaching and Learning (CETL) of Central Michigan University (CMU).
- Oct 2015 Attended workshop on “*Next Steps for New Faculty: Surviving Your First Year in the Professoriate*” offered by CETL of CMU.
- Dec 2015 Attended “*IEEE Virtual Workshop on Early Career Faculty Development: Creating a Research Program – A Global Perspective*”, offered by IEEE.
- Apr 2016 Attended workshop on “*Personalized Professional Development – Taking Charge of Your Own Learning Needs*” offered by CETL of CMU.
- Nov 2016 Attended workshop on “*Successful Integration of Social Media into Your Instruction*” offered by CETL of CMU.
- Nov 2016 Attended workshop on “*Successful Grant Writers Panel*” offered by Office of Research and Graduate Studies (ORGS) of CMU.
- Jan 2017 Attended workshop on “*Internationalizing Your Course – Offering Students a 21st Century Education*” offered by CETL and Office of International Affairs of CMU.
- Aug 30, 2017 Attended workshop titled “*New Hire Orientation – Day 1*,” offered by Eastern Michigan University (EMU). Location: Halle Library.
- Aug 31, 2017 Attended workshop titled “*New Hire Orientation – Day 2*,” offered by EMU. Location: Halle Library.
- Sep 27, 2017 Attended workshop titled “*New Faculty Learning Community – Session 1*,” offered by Faculty Development Center (FDC) of Eastern Michigan University (EMU). Location: Halle Library.
- Sep 27, 2017 Attended workshop titled “*Internal Research Award Application Writing Workshops 2017-2018*,” Session 1 for Summer Research/Creative Activity Award (SRA), offered by FDC of EMU. Location: Halle Library.
- Oct 18, 2017 Attended workshop titled “*New Faculty Learning Community - Session 2*,” offered by Faculty Development Center (FDC) of EMU in Halle Library.
- Oct 13, 2017 Attended workshop titled “*New Faculty Research Orientation and Luncheon*,” offered by Office of Research and Development and Administration (ORDA) of EMU. Location: Lake House.
- Oct 19, 2017 Attended workshop titled “*Tips for Successful Undergraduate Research Stimulus Program Applications*,” offered by ORDA of EMU. Location: Science Complex.
- Oct 24, 2017 Attended workshop titled “*Internal Research Award Application Writing Workshops 2017-2018*,” Session 2 for Summer Research/Creative Activity Award (SRA), offered by FDC of EMU. Location: Halle Library.
- Oct 24, 2017 Attended webinar titled “*Getting Your Research Writing Done at EMU Workshop*,” offered by FDC of EMU.
- Nov 15, 2017 Attended workshop titled “*New Faculty Learning Community -Session 3*,” offered by FDC of EMU. Location: Halle Library.
- Jan 5, 2018 Attended workshop titled “*Culture of Research Excellence (CoRE) 2017-2018 Grant Writing Program*,” offered by ORDA of EMU. Location: Boone Hall.
- Jan 9, 2018 Attended workshop titled “*Internal Research Award Application Writing Workshops 2017-2018*,” Session 1, for Faculty Research Fellowship (FRF), offered by FDC of EMU. Location: Halle Library.
- Jan 18, 2018 Attended workshop titled “*Writing Group for Winter Semester 2018*,” offered by EMU. Location: Halle Library.

Jan 19, 2018	Attended workshop titled <i>"Culture of Research Excellence (CoRE) 2017-2018 Grant Writing Program,"</i> offered by ORDA of EMU. Location: Boone Hall.
Jan 19, 2018	Attended workshop titled <i>"New Faculty Learning Community - Session 4,"</i> offered by FDC of EMU. Location: Halle Library.
Feb 1, 2018	Attended workshop titled <i>"Writing Group for Winter Semester-2018,"</i> offered by EMU. Location: Marshall.
Feb 2, 2018	Attended workshop titled <i>"Culture of Research Excellence (CoRE) 2017-2018 Grant Writing Program,"</i> offered by ORDA of EMU. Boone Hall.
Feb 9, 2018	Attended workshop titled <i>"Culture of Research Excellence (CoRE) 2017-2018 Grant Writing Program,"</i> offered by ORDA of EMU. Boone Hall.
Feb 15, 2018	Attended workshop titled <i>"Writing Group for Winter Semester 2018,"</i> offered by EMU. Location: Marshall.
Feb 16, 2018	Attended workshop titled <i>"New Faculty Learning Community - Session 5,"</i> offered by FDC of EMU. Location: Halle Library.
Mar 15, 2018	Attended workshop titled <i>"Writing Group for Winter Semester 2018,"</i> offered by EMU. Location: Marshall.
Mar 16, 2018	Attended workshop titled <i>"New Faculty Learning Community - Session 6,"</i> offered by FDC of EMU. Location: Halle Library.
Sep 27, 2018	Attended meeting titled <i>"Faculty Lunch with Provost Longworth,"</i> offered by Division of Academic and Student Affairs of EMU. Location: McKenny Hall.
Sep 27, 2018	Attended workshop titled <i>"Internal Research Award Application Writing Workshops 2017-2018,"</i> Session 1 for Summer Research/Creative Activity Award (SRA), offered by FDC of EMU. Location: Halle Library.
Feb 7, 2019	Webinar: Should You Trust Your Gut? Leadership Myths Busted for Technology Professionals, offered by IEEE-USA Leadership Connection.
Feb 14, 2019	Attended webinar titled <i>"Auto-grading labs for web programming,"</i> offered by Dr. Alex Edgcomb from zyBooks.
Jun 18, 2019	Attended webinar titled <i>"Learn How IEEE Uses STEM eMentoring to Help Inspire the Next Generation of Engineers,"</i> offered by IEEE, Executive Director Steve Welby.
Oct. 14, 2019	Attended workshop titled <i>"Internal Research Award Workshop,"</i> offered by Faculty Development Center (FDC) of EMU in Halle Library.
Nov 19, 2019	Attended webinar titled <i>"Engaging Students in the Introduction to Programming Classroom,"</i> offered by zyBooks.
Nov 26, 2019	Attended webinar titled <i>"Teaching Innovations in Computer Science,"</i> offered by Dr. Frank Vahid from zyBooks.
Mar 16, 2020	Attended webinar titled <i>"Webinar Tools and Zoom,"</i> offered by EMU.
Apr 15, 2020	Attended webinar titled <i>"A Faculty-Led Webinar on Engineering Exams in the Remote Classroom,"</i> presented by Dr. Jim Stone from AccessEngineering, McGraw-Hill.
May 6, 2020	Attended webinar titled <i>"Machine Learning in Action,"</i> presented by Georgios Kapetanvasileiou, Lead Data Scientist, SAS.
Jun 3, 2020	Listened recorded webinar titled <i>"Flexible Course Delivery,"</i> presented by Dr. B. Jean Mandernach, Center for Innovation in Research and Teaching, Grand Canyon University.
Jun 11, 2020	Attended webinar titled <i>"Basic TCP/UDP/IP network protocols for future engineers,"</i> presented by Sharan Kalwani from IEEE.
Jul 7, 2020	Attended webinar titled <i>"Introduction to IoT/ Innovative & futuristic Applications of IoT,"</i> presented by Sharan Kalwani from IEEE.
Jul 11, 2020	Attended webinar titled <i>"Build with Deepstream, deploy and manage with AWS IoT services,"</i> from NVIDIA.

- Jul 31, 2020 Listened recorded webinar titled *"Python for IoT Edge Devices,"* presented by Rahul Dubey and Valter Minute from Doulos.
- Aug 14, 2020 Attended webinar titled *"Bare Metal or RTOS? The answer is not as you might think,"* presented by Dr. Des Howlett from Doulos.
- Aug 19, 2020 Attended webinar titled *"The Learning Model That's Proven to Work for COVID-Era Teaching,"* presented by Kevin Barnes, organized by ATS Lab Midwest.

TECHNICAL SKILLS AND EXPERTIES

- **Microcontroller:** TI CC2540 System on Chip using IAR Embedded Workbench, ARM Cortex M4 using Keil, AVR XMEGA using BASCOM AVR and Atmel Studio, Freescale 9S12 microcontroller using CodeWarrior, Arduino UNO, Raspberry Pi using Python.
- **Programming language:** C, C#, C++, HTML, JavaScript, BASIC, Visual C#, Visual Basic, Python, VHDL, Verilog, SystemC, SQL, MySQL, PHP.
- **FPGA:** Altera Cyclone using Quartus, Lattice MACHXO2 using Diamond, Xilinx FPGA based system design using Xilinx ISE and Vivado.
- **ASIC:** CMOS 180nm digital chip design fabrication and testing using Synopsys Design Analyzer and Cadence Encounter, VLSI design simulation using Cadence Virtuoso.
- **PSpice and MATLAB** simulation, image processing.
- **CAD:** AutoCAD, AutoCAD Electrical.
- **App development** in Android and Windows platform with B4A and Microsoft Visual Studio.
- **PCB Design** with Eagle, soldering.

SERVICE EXPERIENCE

Committee Involvement in Eastern Michigan University

- Instructional Committee (Fall 2017 – Winter 2018)
- Strategic Planning Committee (Fall 2017 – Winter 2019)
- School Grade Grievance Committee (Fall 2017 – Winter 2018)
- COT Grade Grievance Committee (Fall 2017 – Winter 2019)
- Engineering Faculty Committee (Fall 2017 – Present)
- IEEE Committee (Fall 2017 – Present)
- Muslim Student Association Representative Committee (Fall 2017 – Present)
- Search Committee for Information Assurance in SISAC (Fall 2018 – Winter 2019)
- University Research and Sabbatical Leave Committee (URSLC) (Fall 2018 – Winter 2019)

Organizer Committee and Volunteer Involvement

- Judge for Senior Project, Michigan Islamic Academy, May 29, 2019.
- Coach in FIRST LEGO League Jr., Mission Mason Expo on May 25, 2019.
- Co-Supervisor in Washtenaw Elementary Science Olympiad - Circuits Event, Pioneer High School, May 11, 2019.
- Research participant in Strategic Alignment in Higher Education, Wayne State University, Feb 14 to Feb 28, 2019.
- Judge in Automotive Services, Michigan Distributive Education Clubs of America (DECA) Conference, Eastern Michigan University, Ypsilanti, MI, USA, Jan 10, 2019.
- International Virtual Conference on Multidisciplinary Research (IVCMR-2018), Walnut, CA, USA, November 14, 2018.

- International Conference on Embedded Systems and Applications (EMSA-2018), Melbourne, Australia, February 17- 18, 2018.
- Judge in Automotive Services, Michigan Distributive Education Clubs of America (DECA) Conference, Eastern Michigan University, Ypsilanti, MI, USA, Jan 12, 2018.

Technical Reviewer

- IEEE Access (*Reviewed 1 journal article*)
- IEEE Transactions Medical Imaging (TMI). (*Reviewed 2 journal articles*)
- IEEE Transactions on Biomedical Circuits and Systems (TBIOCAS). (*Reviewed 1 journal article*)
- IEEE Transactions on Circuits and Systems II (TCAS-II). (*Reviewed 1 journal article*)
- IEEE Journal of Biomedical and Health Informatics (JBHI). (*Reviewed 1 journal article*)
- MDPI journals (*Reviewed 8 journal articles*)
- Signal, Image and Video Processing, Springer. (*Reviewed 1 journal article*)
- Machine Vision and Applications, Springer. (*Reviewed 1 journal article*)
- Computer Methods and Programs in Biomedicine (CMPB), Elsevier. (*Reviewed 1 journal article*)
- Multimedia Systems, Springer. (*Reviewed 1 journal article*)
- Journal of Real-Time Image Processing, Springer. (*Reviewed 1 journal article*)
- BMJ Open Gastroenterology. (*Reviewed 1 journal article*)
- British Journal of Applied Science & Technology. (*Reviewed 1 journal article*)
- International Journal of Embedded Systems and Applications (IJESA) (*Reviewed 2 journal articles*)
- Advances in Science, Technology and Engineering Systems Journal (ASTESJ).
- International Conference on Electrical and Computer Engineering (ICECE), Dhaka, Bangladesh, 2014. (*Reviewed 3 papers*)
- IEEE Innovations in Information Technology (IIT) conference, Al-Ain, UAE, 2013. (*Reviewed 1 paper*)
- Middle East Conference on Biomedical Engineering (MECBME), Doha, Qatar, 2014. (*Reviewed 1 paper*)
- International Conference on Embedded Systems and Applications (EMSA-2018), Melbourne, Australia. (*Reviewed 1 paper*)
- International Conference on Signal, Image Processing and Embedded Systems (SIGEM 2018), April 28-29, 2018, Dubai, UAE. (*Reviewed 2 papers*)
- International Conference on Natural Language Computing (NATL 2018), April 28-29, 2018, Dubai, UAE. (*Reviewed 1 paper*)
- International Virtual Conference on Multidisciplinary Research 2018, November 14, 2018, Walnut, USA. (*Reviewed 1 paper*)

Session Chair

- Session FP2 - Cloud, Mobile, and Distributed Computing, IEEE International Conference on Electro Information Technology (EIT 2018), Rochester, Michigan, USA, May 2018.
- IEEE North Saskatchewan Graduate Research Symposium, University of Saskatchewan, Canada, December 2012.
- IEEE North Saskatchewan Graduate Research Symposium, University of Saskatchewan, Canada, December 2013.

Membership

- Senior Member, *Institute of Electrical and Electronics Engineers (IEEE)*.