Bharath Sudharsan

Status: Researcher, Engineer
Fields: Embedded System, Edge Analytics, Applied Machine Learning, Deep Model Optimization
Activities: Research Implementation & Demonstration, Lecturing, Conference Paper Reviewer
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Education

Ph.D. Data Science Institute, NUIG, Ireland — May 2019 - Present

I am a Ph.D. student advised by Prof. John G Breslin. My research interests/areas include the following.

· Design and implement algorithms to improve the Resilience, Interoperability, Scalability (RIS) of IoT devices.

· Deep optimization, deployment, and efficient execution of a wide range of ML models on AIoT boards, small CPUs, and MCUs based devices.

· Design resource-friendly ML model training algorithms to transform billions of tiny IoT devices into intelligent devices that can locally build their own knowledge base *on-the-fly*.

· Publications: Please visit my Google Scholar profile. [Link]

MEngg in Electronics and Computer Engineering NUIG, Ireland — 2018 - 2019

· Core modules: Computer Security and Forensic Computing, Artificial Intelligence, Mobile Device Technologies, Embedded Image Processing, Electronic Sports Performance and Technology. Below is the applied research projects that I did during my masters, under the supervision of Prof. Peter Corcoran.

· Project, Demo & Publication: Smart speaker design and implementation with biometric authentication and advanced voice interaction capability. 27^{th} AIAI Irish Conference on Artificial Intelligence and Cognitive Science.

· Project, Poster & Publication: AI Vision: Smart speaker design and implementation with object detection custom skill and advanced voice interaction capability. 11^{th} International Conference on Advanced Computing.

· Project & Publication: Unsupervised method to analyze playing styles of EPL teams using ball possession-position data. 7^{th} International Conference on Advanced Computing & Communication Systems.

· Project: A microphone array and voice algorithm based smart hearing aid. arXiv Preprint.

Work Experience

Researcher CONFIRM SFI Research Centre for Smart Manufacturing, Ireland — May 2019 - Present

Below is the list of applied research projects that I contributed to as a researcher at CONFIRM.

· We built *COVID-away models* to reduce the spread of the current global pandemic. When our model is deployed on smartwatches, it can trigger a timely notification (e.g. vibration) when the hand of the smartwatch user is moved (unintentionally) towards the face. This work is featured on the Confirm website and made available on the WHO's global literature on coronavirus disease page. Also won Second place in IoT-HSA'20 workshop.

· We designed *Edge2Guard*, which are botnet attacks detecting models for resource-constrained IoT Devices. Our resource-friendly standalone attack detecting Edge2Guard models enable MCU-based IoT devices to instantly detect IoT attacks without depending on networks or any external protection mechanisms.

· We designed *Adaptive Strategy* to improve the quality of communication for IoT edge devices. When devices within an IoT system are equipped with our strategy, they can adapt according to dynamic context whilst ensuring the highest level of communication quality, thus, improving the overall resilience of the entire IoT system.

· We are currently working towards building *OWSNet* for consumer IoT devices, which is a real-time offensive words spotting network. Our OWSNet is designed to ensure a healthy verbal environment and avoid harmful incidents by policing the usage of language.

Research Paper Reviewer - International Conferences and Workshops — May 2019 - Present

· My role as a reviewer at WF-IoT, GIoTS, IoT-HSA, ICMLT, IoT, CD-MAKE, and ICISDM is to evaluate submissions based on the quality, completeness, and accuracy of the presented research. Also, provide feedback on the submitted article, suggest improvements and make a recommendation to the editor about whether to accept, reject or request changes to the article.

Teaching Experience - NUI Galway, Ireland — Jan 2020 - Present

· 2021: Lab supervisor for Microprocessor Systems Engineering (EE224), Electrical Circuits and Systems (EE230) @ School of EEE. Teaching Support Staff (TSS) for Research Skills in Artificial Intelligence (CT5144), Data Visualisation (CT5100), Web and Network Science (CT5113) @ School of CS.

· 2020: TSS for Professional Skills - I (CT1112) and 2nd reader/examiner @ School of CS. TA for Fundamentals of EEE - I (EE130), Fundamentals of Engineering (EI140) @ School of EEE.

R&D - Embedded System Engineer - Four Corners Technologies (4CT) Pvt. Ltd, India Oct 2016 - Nov 2018

At 4CT, we developed IoT smart solutions for retails, workspace, kiosks, and outdoor billboards. I was the hardware guy in this firm, where my role was to design-build-program the wireless embedded system (hardware) of the devices, then connect its data stream to their cloud services. Below is the project list that I contributed to.

· Workspace Occupancy Monitoring: We designed a wireless embedded system with Panasonic Grid Eye thermal sensor to monitor the workspace occupancy. This occupancy data was sent to our web app to generate client requirement-based meaningful insights such as; Rich visualization & reporting of building & workspace utilization, detailed occupancy patterns, extensive reporting of occupancy by department & by function, etc.

· Remote Hoardings Monitoring: We designed an IP66 grade Linux-based IoT camera with 4G connectivity and integrated multiple outdoor LDR sensors. 250 of our IoT cameras were installed across the state to monitor the outdoor billboards to provide view clarity, material & installation quality, pillar quality, lighting quality, live stream, etc when requested by the billboard owners or clients via our billboard management system.

· Retail Sense, 'Progressive business decisions with live data at your fingertips'. We designed Retail Sense, which is a low-cost camera-based wireless footfall people counter. The raw footfall count was sent to our web app, where it was converted into meaningful information that revealed patterns and profitable insight which was used to make key decisions on; ideal staffing levels and placement based on the hour, day, month & season, facility's layout and operations, etc.

· e-Health Kiosks: We designed an MCU based embedded system with Height (MaxBotix Ultrasonic), Weight (load cells mapped to a 24 bit ADC) & Heart rate (Max30100 Pulse Oximetry) sensors interfaced with it. This board computes the height (cms) weight (Kgs) and heart rate (BPM & SPO2) and sends it to the system of the Digital Signage kiosk via USB.

IoT R&D Intern - Flamenco Tech India Pvt. Ltd Jun – Aug 2016

· Sensor Integration into client's smart parking system: Installed and integrated hundreds of ceiling, parked car detection ultrasonic sensors into client's smart parking system.

Skills

Embedded Hardware Design for Offline and Real-time IoT Edge Analytics

· Multi-sensor, wireless, Low-power Embedded system design using various ARM MCUs. Embedded architecture-aware software development using PICCCS, Keil, or other Embedded development Tools, IDEs & Debuggers.

· Experienced working in power-constrained typologies-based wireless environments. Solid knowledge of wireless & wired communication systems, protocols & peripherals such as BLE, Wi-Fi, LTE, GPS/GNSS, CoAP, MQTT, 6LoWPAN, Z-Wave, ZigBee, LoRaWAN, SigFox, AMQP, XMPP, HTTP/2.0. Digital, Analog, I2S, USB, UART, CAN, I2C, SPI, RS232 & RS485.

· Hands on embedded system design experience using Panasonic's PaPIRs, Grid-EYE infrared arrays, MaxBotix's range finders, Maxim Integrated's healthcare sensors, Thermoelectric Peltier Modules, Interlink FSRs & Flex sensors, Melexis contactless IR temp sensor, ST's FlightSense ToF technology, ReSpeaker mic-arrays, and others.

· Schematic Capture, PCB Layout, Fab package release (Gerber, Drill, BOM, etc.) to build mixed-signal hardware using Proteus or Eagle.

· Experienced using Digi's wireless SOCs & networks, IntelMovidius NCS, Nvidia Jetson Nano, Leap motion, other SBCs & MCUs like Raspberry Pis, Intel NUC series, Google Coral, LattePanda boards, STM32 blue pills, Espressif modules, Nordic SoC's, Arduino boards, etc.

Write Deployment Ready IoT Applications in C, Embedded C, C++, Python

· Design, build, maintain efficient & reliable code.

· Familiar with Unix environment, Shell scripting and Git-based source control system.

· Writing code utilizing concepts from multi-threading, RTOS, OOPS. Experienced using inline functions, volatile keywords, macros, interrupts, virtual, friend functions, etc.

· Experienced in setting up hosting environments such as Azure, ThingsSpeak, Dweet, IBM Watson, Node-Red, Digital Ocean, AWS, etc. Then connect the data stream from IoT edge devices to thus configured remote cloud for IoT analytics, historical data storage, etc.

· Firm experience in selection of hardware budget and computation requirement based chips i.e. from a range of 8, 16 & 32-bit MCUs, microprocessors, FPGAs, and programing them to solve a wide range of problems in the given IoT use-case.

Use case based ML Model Creation, Deep Optimization, and Deployment

· A solid foundation on Neural Network components such as weights, activation function (such as Sigmoid, Tanh, Softmax, ReLU), different types of network layers (such as Conv1D, DepthwiseConv2D, MaxPool1D, Dropout, Average, Reshape, etc.), training, validation, testing process, gradients, partial derivatives, chain rule, backpropagation, optimizers (such as GD, SGD, mini-batch GD, Adam), loss functions, etc. Experienced in implementing various types of NNs in Keras, Tensorflow Lite, and using Numpy, SciPy, Pandas for precomputing.

· Exposure to Deep Learning with classical computer vision techniques for image recognition, object detection & tracking, and acoustic scene identification.

· Experienced in optimizing model size, workload, operations, perform quantization-aware training and post-training quantization. Converting and stitching models with main IoT application/program, followed by building executable binaries and deployment on any given hardware.

· Firm knowledge in designing resource-friendly end-to-end advanced edge analytics, signal processing, and computer vision pipelines.

· Solid understanding of popular models such as MobileNet, SqueezeNet, Inception V1, MnasNet, NASNet mobile, DenseNet, DeepLabv3, PoseNet, EAST, etc. Experienced in optimizing such models in multiple aspects, followed by their efficient deployment and execution on any target device. Design of use-case based anomaly detection, forecasting & classification model, followed by its hardware-software co-optimization and deep compression to enable its accomodation on resource-constrained devices.

ML Datasets Creation, Analysis, Processing and Visualization

· Perform Exploratory Data Analysis (EDA) for a given dataset and generate profile reports that contains; quantile statistics, descriptive statistics, most frequent values, histogram, correlations, missing values, file and image analysis, text analysis, etc.

· Experienced in building ML datasets: Recently created a multi-sensor dataset named COVID-away. It contains the recording of accelerometer, gyroscope, barometric pressure & rotation vector data for 2071 dynamic hand-to-face movements, performed with various postures (standing, leaning, slouching, etc.) and wrist orientations (variations in Roll, Pitch, and Yaw). Frequent usage of data visualization Plotly, Seaborn and Matplotlib libraries in research environment to present ML model performance, visual comparison of various analytics results, etc.

Grants Won

ARMS glove for Stroke - Blackstone Launchpad - NUIG — Nov 2018 - Feb 2019

· Project, Poster & Bench Demo: Post hand paralysis or injury, patients often require lengthy, repeated and therapists supervised clinical training to regain muscular control and function. Using the grant, we built a wearable named Assess, Respond, Monitor, Strengthen (ARMS) glove that facilitates patients to perform various supervised interventions at their convenient place and time without the presence of therapists.

Liveliness Detection Sub-system for Digital Voice Assistants - Launchpad — Nov 2019 - Mar 2020

· Using the grant, we designed a light-weight Infineon radar-based sub-system and integrated it with Alexa digital voice assistance. Our sub-system enables Alexa to intelligently differentiate live human voices from voices coming out of speakers, thus making Alexa not react to voice commands from non-lively objects.

Milestones

Paper: Avoid Touching Your Face - IoT-HSA 2020 — Oct 2020

· Presented our paper titled "Avoid Touching Your Face: A Hand-to-face 3D Motion Dataset (COVID-away) and Trained Models for Smartwatches" in IoT-HSA workshop and won the Second place.

Smart Portable IoT Vaccine Monitor - Mouser IoT Design Contest — Dec 2015 - Jul 2016

· Second place, National level, India: When the environment is not optimal, the efficacy of vaccines is lost, especially when health workers carry vaccines in a portable box during door-to-door polio campaigns. Our device continuously monitors the vaccines using multiple sensors and runs local analytics to ensure vaccine efficacy is preserved. The timely alerts from our device prevent administering less potent vaccines during campaigns.

Gesture Control Glove - Atmel India University Program Embedded design contest — Oct 2015 - Apr 2016

· Finalist, National level: During seminars/presentations, to provide a seamless user-machine interaction, we built a wireless sensor-based wearable that helps the presenter achieve improved synchronization while performing presentation control tasks such as window switching, scrolling, slide navigation, audio-video controls, etc.

Secure Baggage using PSc - OpenGovDataHack Oct 2017 - Nov 2018

· PSc is a sensor-based embedded system with BLE, which we built to act as a virtual locker for securing the belongings of passengers using public transports. We were the runner up of NIC-IAMAI #OpenGovDataHack conducted across 7 cities nationwide and qualified for final presentation before Shri Ravi Shankar Prasad, Minister of Electronics & Information Technology, Govt of India. The project also got nominated for Tata Consultancy Services (TCS) best project award.

Professional Development Courses

Please visit the Professional Development Courses tab on my homepage to view the full list. [Link]

Google IT Automation with Python (Professional Certificate) - Google via Coursera Nov 2020

· Configuration Management and the Cloud. Crash Course on Python. Using Python to Interact with the OS. Introduction to Git and GitHub. Troubleshooting and Debugging Techniques. Automating Real-World Tasks.

Industrial IoT Markets and Security - University of Colorado Boulder via Coursera Nov 2020

· Automation deployment, IIoT software and services market, Real-time operating system for an IIoT node, Networking, wireless communication providers and protocols, Network Functions Virtualization and Software Defined Networks, Security solutions for end-node type devices.

Open Source and the 5G Transition - LinuxFoundationX via edX Jul 2020

· Open 5G network, Standards & software, Integrating 5G into business strategy, Considerations & going forward.

Applied AI with DeepLearning - IBM via Coursera Aug 2019

· DeepLearning Frameworks (Keras, TensorFlow, SystemML & DeepLearning4J), DeepLearning Applications (Anomaly Detector, Time Series Forecasting, Image classification & Sequence Classification), Scaling and Deployment (IBM Watson Visual Recognition, Tasks in ApacheSpark using DL4J & SystemML).

Cybersecurity & the Internet of Things - University System of Georgia via Coursera Jan 2019

· Organizational Risks in industrial Sector, Application in Smart Grid, Security & Privacy Issues, Interoperability & Security issues, Connected Home & Community, Consumer Wearables (Wearable Computing, Objective Metrics, Quantified Self).

MediaTek Smartphone Design Training Program - India & Taiwan Apr 2018

· Mobile design process, Performance testing & tuning, Basic BSP knowledge, Taiwan mobile phone eco-system tours, Real practice in MediaTek, Digital /Analogue /Cellular RF /Wireless Connectivity /Multimedia relative knowledge, Camera/Audio tuning, Power consumption & thermal design, Certification & regulation, Case study (measurement and debugging), Mobile market segmentation & positioning.

Architecting Smart IoT Devices - EIT Digital via Coursera Jun 2018

· Hardware & Software for EmS (MCU, SOC, FPGA, Cache, pipeline & coupling, Sensor Networks, Protocol stacks, Licenses, SensorTag Experiment), RTOS (Real-time Scheduling, Synchronisation and Communication, Device Drivers), System Finalisation (Code Tuning, Security, Realtime & Logical remote debugging, Simulation on host).

Fundamentals of Digital Image and Video Processing - North western University Dec 2016

· Signals & System, Fourier Transforms & Sampling, Motion Estimation, Image Enhancement, Image Recovery, Lossless Compression, Video Compression, Image & video segmentation, Sparsity.

Introduction to Linux - LinuxFoundationX via edX Apr 2016

· Linux Philosophy & Community, Partitions, Filesystems, Boot process, Environment Variables, Permissions, Security, Commandline, Encryption, Bash Shell Scripting & Debugging.

References

- Dr. Muhammad Intizar Ali, Asst Professor in School of Electronic Engineering, Dublin City University. [Link]
- Prof. John G Breslin, Director of TechInnovate and Professor in Electronic Engineering at the National University of Ireland Galway. [Link]
- Madhusudhan Rao, Managing Director at Four Corners Technologies Pvt. Ltd. [Link]