September 2021

Welcome Message from Editor and Team!

Welcome to Fall!

We welcome you to September issue of IEEE Newsletter, Toronto section.

In this issue, enjoy reading article "Machine Learning for Indoor Positioning". **(Page 2)**

Meet Dr. Xavier N Fernando in our IEEE supporters section. Enjoy and appreciate his contributions to IEEE.

For the section upcoming events, please visit New Events page.

You can find newsletter's previous issues here. You can explore our Library to access links to various newsletters, resources and chapter activities.

By launching this newsletter, we intend to cover IEEE achievements and success stories specific to the Toronto area.

If you have any questions, suggestions, or concerns, please address them to the editor; Fatima Hussain at fatima.hussain@ryerson.ca. We hope to hear from you, and we welcome your feedback!

Meet Our Distinguished IEEE Members

XAVIER N. FERNANDO

XAVIER N. FERNANDO was born in Colombo, Sri Lanka in 1965. He received B. Sc. Eng. (First Class Hons) degree in Electrical and Electronic Engineering at the University of Peradeniya, Sri Lanka in 1992 and Master's degree in Telecommunications at the Asian Institute of Technology, Bangkok, Thailand in 1994. He obtained his PhD degree at the University of Calgary, Canada in 2001 in Electrical and Computer Engineering specializing in wireless communications.

He worked as an R&D Engineer for AT&T (Thailand) from 1994 to 1997. Currently he is a Professor at Ryerson University, Toronto, Canada. He was a visiting scholar at the Institute of Advanced Telecommunications (IAT), UK in 2008 and MAPNET Fellow visiting Aston University, UK in 2014. He has published a monograph, 'Radio over Fiber for Wireless Communications' (IEEE Wiley, 2014) and co-authored 'Cooperative Spectrum Sensing and Resource Allocation Strategies in Cognitive Radio Networks' (Springer, 2017) and 'Vehicular Applications of Visible Light Communications' (IOP Publications, 2020). He has also co-authored 58 journal papers and 126 Conference Papers including many invited papers. His current research interests are wireless communication and positioning. His previous interests are radio over fiber and underground communication systems.

Dr. Fernando is a Senior Member of IEEE and a licensed Professional Engineer in Ontario. He was an IEEE Communications Society Distinguished Lecturer and delivered over 60 invited talks and keynote presentations. He was the Chair of IEEE Toronto Section and Chair of IEEE Canada Central Area. He has been in the organizing/steering/technical program committees of numerous conferences. His work has won 30 awards and prizes so far including, Professional Engineers Ontario Award in 2016, IEEE Microwave Theory and Techniques Society Prize in 2010, Sarnoff Symposium Prize in 2009, Opto-Canada best poster prize in 2003 and CCECE best paper prize in 2001.

Machine Learning for Indoor Positioning

XAVIER N. FERNANDO, (Senior Member, IEEE)

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Accurate real time positioning is the key to enable location-based services (LBS). Although the global positioning system (GPS) is widely used for localization in outdoors, the GPS usability is not satisfactory in the confined indoor environments. Unlike outdoor, indoor environments are very complex with varying shapes, sizes with the presence/absence of stationary and moving objects (e.g. furniture and people). These factors significantly alter both line-of sight (LOS) and non-line of sight (NLOS) radio signal propagation causing unpredictable attenuation, scattering, shadowing and blind spots that significantly degrade the accuracy of indoor positioning.

However, due to the high demand for LBS, significant attention has been made on the development of indoor positioning systems (IPS) recently. Typical ranging techniques based on received-signal-strength-indicator (RSSI), time-of-arrival (ToA), time-difference-of-arrival (TDoA), angle-of-arrival (AoA), and channel-state-information (CSI) have been proposed. Most ranging techniques require at least three known anchor nodes to calculate the location of the unknown target.

All these approaches suffer from multitude of challenges including poor accuracy, high computational complexity, and unreliability while, most positioning devices lack strong processing power. In addition, the ability to maintain big databases (for large scale IPS) while ensuring security and privacy, and supporting device heterogeneity at a reasonable cost are some other challenges in indoor localization.

In recent years, artificial intelligence (AI) and machine learning (ML) algorithms find good success in indoor localization. The main advantage of AI/ML approaches is their ability to make decisions effectively using observed data without accurate mathematical formulation. ML has also proven as an effective way to fuse multi-dimensional data collected from multiple positioning sensors, technologies and methods. Both supervised and unsupervised learning can be applied for fusion weight generation. However, unsupervised ML fusion technique is superior since it calculates the weights in real-time without offline training.

In localization, classifier algorithms are mainly used to extract core features of the signals. In fingerprint-method clustering is performed based on these extracted features. Feature extraction is also important for NLOS identification and mitigation. K-NN, Support-Vector Machine (SVM), Random Forest, Decision Tree and, Artificial Neural Networks (ANN) are widely used classification algorithms.

However, in complex environment scenarios where features extraction is difficult and data has high dimensionality, DL is very promising to improve localization accuracy. DL is well known for its distributed computing capability and analyzing of a huge volume of unlabeled and un-categorized data. The biggest advantage of DL algorithms is their ability to extract features from data directly without manual feature extraction. This eliminates the need of domain expertise and extraction of hard core features. Feature extraction and classification are carried out by a DL algorithm known as Convolutional Neural Network (CNN).

Many of the indoor positioning approaches are vulnerable to global positioning error and kidnapped-robot problems. The global localization problem occurs when the initial position of the target is unknown to the IPS during initialization. While kidnapped-robot problem occurs when a well-located target moves to an unknown environment. In such a challenging situation, RL proves to be the best technique to use. As RL enables the agent to achieve a long-term objective by interacting with the environment (based on the reward and penalty process), and are able to solve problems caused by radio signal instability. Therefore, RL techniques are able to construct the map and optimize its action continuously, thus proved as promising solution for indoor positioning.

Get Involved with Us!

IEEE Toronto section is looking forward to hearing from you. your contributions are welcome to this monthly newsletter. We invite our members to share and submit:

- Short Story (about IEEE members, WIE members)
- News items and Affinity group reports
- Technical Articles/Blogs (Brief discussions of cutting edge research, new technological tools, topics of your choice)

Submission

Articles should be submitted in Word format. Word count for News items, Affinity group reports is 50 to 200 words and for blogs/ articles is 500 to 800 words.

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