

# **Motivation of Embedded Intelligent Systems**

## **Elective (EIS) Roll out**

The motivation behind the courses is the huge demand in jobs in area of machine learning and deep Learning. Recent breakthroughs in deep learning and artificial intelligence technologies have enabled numerous mobile applications. While traditional computation paradigms rely on mobile sensing and cloud computing, deep learning implemented on mobile devices provides several advantages. These advantages include low communication bandwidth, small cloud computing resource cost, quick response time, and improved data privacy. Research and development of deep learning on mobile and embedded devices has recently attracted much attention. Hence, we had EIS offering the learning of latest deep learning applications on target mobile devices exposing students to latest cutting edge technologies used in the industry.

## **EIS Course Development in collaboration with**

### **Samsung R & D , Bengaluru (SRIB)**

The EIS group at KLE Technological University has been actively involved in research and development with numerous publications, and industry driven research projects. With equal focus on deep learning, the curriculum covers all facets of the embedded intelligent systems with special focus on research problems. Topics include various domains including embedded systems, kernel programming, heterogeneous computing, Deep Learning and Optimization, and Android anatomy. The EIS group is driven by distinguished faculty Dr Meena S M and Dr Uma M. Dr Meena S M and Dr Uma M are renowned in this field, for their contributions through papers published in reputed journals and conference proceedings, guest lectures at various universities and conferences.

The EIS initiatives at the University are jointly handled by In-house faculty and industry experts.

- Dr. Balaji Holur , Senior Vice President , Samsung Research a& Development , Bengaluru
- Dr. Lokesh Boregowda, Director, Samsung Research & Development , Bengaluru

To get an industry like experience of deep learning technology on mobile devices using Android, from concept to model deployment, selected faculty have undergone training at Samsung R&D Bengaluru from July 14 to July 22, 2018. The trained faculty jointly with industry experts, developed this course. As part of this initiative, an agreement between KLE Tech University and SRIB has enabled design a program, to create a course under the guidance of faculty and industry experts.

# **EIS Course Pedagogy and Delivery**

## **Project Based Learning**

Project-based learning involves dynamic classroom approach in which students acquire a deeper knowledge through active investigation of real-world challenges and problems. Embedded Intelligent Systems course was co-designed and co-delivered by KLE Technological University and Samsung R&D Institute Bangalore (SRIB). Faculty were enabled with learning sessions and workshops by SRIB. The course delivery involved SRIB team delivering sessions as one-day workshops in our campus throughout the semester. The projects were reviewed by in-house faculty and SRIB experts regularly throughout the semester. The laboratory-oriented curriculum consists of weekly sessions of six hours mentored by in-house faculty. In 2018-19, 14 collaborative research projects undertaken at the University which included design and implementation of deep learning algorithms on target hardware.

**Workshops conducted in KLETECHU by SRIB experts**

Android Applications	Android architecture and sample applications	<ol style="list-style-type: none"> <li>1. Android Architecture</li> <li>2. Linux Kernel</li> <li>3. Binder</li> <li>4. HAL</li> <li>5. Native Libraries</li> <li>6. Android Runtime</li> <li>7. Dalvik</li> <li>8. Application framework</li> <li>9. Applications</li> <li>10. IPC</li> </ol>	29/09/18 1 day	<b>Mr Vanraj</b>
Heterogeneous Computing	Heterogeneous computing and lab	<ol style="list-style-type: none"> <li>1. Introduction to parallel computing</li> <li>2. Parallel computing microarchitectures</li> </ol>	06/10/18 1 day	Mr Venkappa and Mr Raj

**Co-teaching and delivery by KLETECH Staff & SRIB Experts**

**Projects undertaken by students as part of course**

Topic	Content(Hours)	KLETECH faculty	SRIB team
1. Basics of embedded systems	10 hours	<ul style="list-style-type: none"> <li>• 8 hours by KLETEch faculty</li> <li>• – Shruti , Priyadarshini</li> </ul>	<ul style="list-style-type: none"> <li>• 2 hours by SRIB ( <b>Sharan and Praveen</b>) – Date : 27/01/19</li> <li>• 10.30 – 12.30 ( theory discussion , Q&amp;A)</li> <li>• 1.30-3.30 ( lab session)</li> </ul>
2. Lab session on embedded systems			
3. Heterogeneous computing	8 hours	<ul style="list-style-type: none"> <li>• 8 hours by KLETEch faculty</li> <li>• – Shridhar, Satish</li> </ul>	<ul style="list-style-type: none"> <li>• 4 hours by SRIB ( <b>Dr Narsingha and Ashok</b>) – Date : 01/01/19 and 16/02/19</li> <li>• 10.30 – 12.30 ( theory discussion , Q&amp;A)</li> <li>• 1.30-3.30 ( lab session)</li> </ul>
4. Heterogeneous computing Lab session	4 hours		
5. ML Frameworks	8 hours	<ul style="list-style-type: none"> <li>• 10 hours by KLETEch faculty</li> <li>• – Kavita , Shilpa and Shrishail</li> </ul>	<ul style="list-style-type: none"> <li>• 6 hours by SRIB ( <b>Dr Sandeep Palakkal</b>) Date: 23/03/19</li> <li>• 10.30 – 12.30 ( theory discussion , Q&amp;A)</li> <li>• 1.30-3.30 ( lab session)</li> </ul>
6. ML Frameworks lab with the target device	8 hours		
7. Model Development and Optimization	8 hours		
8. Android Anatomy	8 hours	<ul style="list-style-type: none"> <li>• 3 hours by KLETEch faculty</li> <li>• – Sunil , Praveen M D</li> </ul>	<ul style="list-style-type: none"> <li>• 5 hours by SRIB ( <b>Vanraj</b> )</li> <li>• Date : 13/04/19</li> <li>• 10.30 – 12.30 ( theory discussion , Q&amp;A)</li> <li>• 1.30-3.30 ( lab session)</li> </ul>

## Project Review Details

<ol style="list-style-type: none"><li>1. Gesture Recognition</li><li>2. Scene Analysis</li><li>3. Multi Object Tracking</li><li>4. Emotion recognition</li><li>5. Scene graph generation</li><li>6. Thin object Segmentation using Image Matting</li><li>7. Super Resolution</li></ol>	<ol style="list-style-type: none"><li>8. Low memory GEMM based convolution</li><li>9. Trie base retrieval subsystem</li><li>10. Offline graph generation</li><li>11. Model Encryption</li><li>12. AI model compression</li><li>13. Image doctoring</li><li>14. Caffe2 , MxNet runtime parser</li></ol>
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Projects were reviewed by SRIB experts regularly by visiting KLETech Campus and on conference calls

### SRIB expert team members:

- Balaji Holur (Sr. Vice President, Samsung R&D, Bangalore)
- Raju Dixit (Senior Director, On Device AI Group)
- Lokesh Boregowda (Senior Principal Engineer)
- Sreevatsa D B (Senior Chief Engineer)
- Sandeep Palakkal (Senior Chief Engineer)
- Venkataramana Peddigari (Senior Chief Engineer)
- Sujoy Saha (Associate Director)
- Basavaraj Vondrotti (Associate Director)
- Praveen Bangre (General Manager, On Device AI Group)
- Venkappa Mala (General Manager, On Device AI Group)
- Vanraj Vala (Senior Principal Engineer)
- Pradeep N S (Senior Principal Engineer)

- **Three reviews by Samsung visiting KLETECH**

Initial review - 24/08/18

Mid review- 24/11/18

Final review- 19/01/18

- **Project progress monitoring review on conference call by SRIB team on following dates:**

16/11/18

20/11/18

22/11/18

18/12/18

## **Outcomes**

- As a result of this initiative, internships have been offered and the associated research work is published by students.
- 12 teams have submitted papers to international prestigious conferences and 2 teams have contributed to opensource