



**NUST**  
School of Electrical Engineering  
& Computer Science

Abstract Booklet

**BEE** Bachelor of  
Electrical  
Engineering

Class of **2022**

Department of

**Electrical Engineering**



Greeting & Message from  
**Principal NUST-SEECs**

**Dr. Muhammad Ajmal Khan, SI(M)**  
PhD (Michigan State University, USA)



It is a pleasure to introduce to you the graduating classes of 2022 in the disciplines of Electrical Engineering, Software Engineering, and Computer Science.

NUST-School of Electrical Engineering and Computer Science (SEECs) is committed to providing first-rate higher education in Pakistan. We emphasize making SEECs a center of excellence for imparting high-quality education in the areas of Electrical Engineering and Computer Science that would lead to the promotion of research and scholarly achievements at National & International levels. We foster a passion for creativity and productivity in our students through an enabling environment of state-of-the-art labs, arranging industry visits, seminars, and international conferences, etc. Besides imparting thorough professional knowledge, we also believe in instilling sound entrepreneurial, social and humanitarian values.

The programs offered at SEECs include Electronics, Digital Systems, RF and Microwave, Telecommunication and Networks, Artificial Intelligence, Machine Learning, Big Data, Cyber Security, and Cloud Computing. Hands-on training in these domains augments the basic knowledge of our students, giving insights into its practical application, an essential prerequisite for potential technical leaders of the 21st century.

The projects showcased in the Open House demonstrate the skill set of our graduating students, and the highly interactive sessions with the industrial professionals provide them a platform for networking. Another aim of holding this event is to address the dire need for industry-academia

partnerships in Pakistan. Through Open House, the industry can witness the outstanding research of various disciplines that are being offered at NUST-SEECs. At the same time, the industry feedback helps us update our curriculum according to the contemporary market trends. Henceforth, I take immense delight in presenting the batch of 2022 as the proud product of SEECs and wish them success as they go forward in their respective fields, with all the best for their journey ahead.





Message from Associate Dean - Department of Electrical Engineering

## Dr. Hassaan Khaliq Qureshi

Professor  
PhD (Electrical Engineering)

### Dear Graduating Students,

The much-awaited time has come for yet another batch of engineering graduates of EE program to enter the real world. I would like to congratulate all our graduating students at this moment of accomplishment, which has come after the successful culmination of four years of hard work and studies. In order to become useful members of the engineering fraternity, you have to continuously learn and get accustomed to the new technologies and trends in engineering.

I wish you all well, and earnestly hope that the future holds promise for you. I believe that all obstacles can be overcome through intrinsic motivation to perform better. So go forth, work hard and make worthy contributions to your profession and society.

## Faculty Heads

**Dr. M. Shahzad Younis**  
Associate Professor  
Ph.D Signal and Image Processing  
University Technology Petronas, Malaysia.  
Head of Digital Systems and Signal Processing



**Dr. Ammar Hasan**  
Professor  
PhD (Control Systems)  
Imperial College London, UK  
Head of Power & Control Engineering



**Dr. Syed Ali Hassan**  
Professor  
PhD (Electrical Engineering)  
Georgia Institute of Technology, USA  
Head of Communication Systems and Networks



**Dr. Muhammad Umar Khan**  
Associate Professor  
PhD (EE)  
King Fahad University of Petroleum and Minerals  
Head of RF & Microwave





## Overview of **OPEN HOUSE**

NUST SEECS organizes its annual open house to show case the skills of its graduating students. The idea is to provide a platform where our students and industry representatives can mingle and have informal or formal discussions. The students showcase their final year projects which represent their skill set and enable potential employers to identify any matching requirements. The projects are presented by students from:

### **Department of Electrical Engineering (DoEE)**

The department of Electrical Engineering has divided its projects into three knowledge areas that are Digital Systems and Signal Processing, Power Electronics and Control, and Communications Systems and Networks. There are a total of 64 projects divided into the above mentioned knowledge groups. Most of the projects are aimed at providing technology based solutions for social problems.

At NUST SEECS, we take pride in molding our bright entrants into well trained and appropriately groomed professionals in Computer Science, Software Engineering & Electrical Engineering. Our graduates are actively sought by the industry and our Alumni are occupying promising positions in some of the most prestigious industrial and business houses, both in public and private sectors. We hope you enjoy the hard work of our students and find the right candidate or the next big idea for your company.

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## Efficient Neural Network Processor Based on RISC-V Vector Extension

**Advisor:** Dr. Muhammad Imran

Vectors and arrays are the main part of any AI (Artificial Intelligence) algorithm and they take most of the computer's time to compute to give accurate results. However, dealing with these kind of large data sets is not easy because to operate on them and to obtain fast and accurate results, we need parallelism of data, i.e., perform two or more operations in a single clock cycle. To perform such operations, we need intensively powerful processing units that can execute vectors and arrays of data in a fast manner.

This report describes the approach, methodology, design and implementation of RISC-V Vector Extension which is an effective solution to efficiently run large sets of data i.e., vectors and arrays. By integrating this microarchitecture with any simple RISC-V32 integer processor, one can obtain a more powerful and reliable processor that can not only perform simple scalar and vector operations but can also operate on variable-sized data.

This report also compares architecture of RISC-V Vector extension with other existing hardware solutions along with the future work that can be carried out using this project. The results obtained through this project are also explained thoroughly.

## Tagging multimedia events for Content Advertisement

**Advisor:** Dr. Muhammad Imran

The major goal of this project is to develop a web-based system that will help people identify successful advertising. As a result, the effectiveness of money spent on online advertising is improved. A list of profitable keyword related advertising, including the keywords, might be generated using an appropriate algorithm and database. This approach will assist advertisers in investing their money in the appropriate keywords and prices, so increasing their expenditure and efficiency.

Users will benefit from solution in the workplaces, banking, health care, language learning, educational, marketing, and other areas. With a low mistake rate, our algorithm will transcribe Urdu speech. We took a step-by-step strategy, designing our acoustic and language models before building our lexicon. These are the basic elements of speech recognition. These are contained within a Transformers model built on deep learning. The produced text is then analyzed in such a way that if it is general speech, our system will display or recommend similar advertisements, and if it is an inquiry that requires responses, it will display advertisements related to its answer. Finally, we developed a web-based GUI that allows us to display and test results for any input.

**Group Members:**  
Fahad Waheed  
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Jibran Zia

## Battery management systems for Li-ion battery packs

**Advisor:** Dr. Usman Ali

There are many electrical devices around us in which battery serves as a primary source of electrical energy. The lithium ion (Li-ion) battery technology family has provided an answer to many of the requirements demanded by emerging mobile and stationary applications, but we know that the chemistry inside the battery is very susceptible to certain risks such as overheating, over-voltage, deep discharge, over-current and pressure or mechanical stress. For this reason, these batteries should be operated inside a safe and well-defined supervising system referred to as Battery Management System (BMS). A battery management system aims to make the battery operation more efficient. This project will focus on Active and passive balancing and compare the results of both. The project will utilize knowledge of Control Systems, Power Electronics and Digital Systems to monitor the following:

- 1-Overcharging
- 2- Undercharging
- 3- Over heating and Over cooling

The electronic system will first be simulated using the simulation softwares and then be implemented on hardware.

## Construction of Variable frequency drive for three-phase Induction Motor

**Advisor:** Dr. Ammar Hasan

This project aims on building a Variable Frequency Drive for a three-phase Induction Motor, one of the most used electric motors. High power induction motors (which we will be using in this project) are widely used in industries and recently have been utilized in variety of applications like electric vehicles, water pumps etc. The Variable Frequency Drive (VFD) is used to control the speed of the motor. Power electronic switches such as IGBT, GTO or SCR switch the DC power at very high speed from rectifier on and off to produce a current or voltage waveform at the required new frequency. Presently most of the voltage source inverters (VSI) use pulse width modulation (PWM) because the current and voltage waveform at output in this scheme is approximately a sine wave. The project also requires knowledge of Embedded System to control operation of VFD. However, the implementation of VFD for high power circuits will be quite challenging but, is considered as one of the crucial tasks. VFD offers important energy-saving opportunities for the induction motor used in various pumps, etc.

**Group Members:**

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## Demonstration of Demand Response Using Thermal Appliances

**Advisor:** Dr. Usman Ali

Demand response refers to changes in electrical usage of end consumers from their normal consumption pattern to improve the performance of the grid. Demand response serves as a steppingstone for further developments in power distribution networks. To achieve these potential benefits, control of users' flexible appliances will be required. However, direct control is difficult to acquire on a large scale due to expensive and invasive installations, but an indirect control of appliance by sending a notification to the user can be acquired conveniently. Blackouts and Load Shedding are a usual practice in Pakistan due to more demand and less supply. Cooling systems such as ACs are also present in every home due to prevailing hot climate of Pakistan. A major chunk of power is consumed by such thermal appliances. A study revealed that an average 1.5-ton Air Conditioner has a power consumption of 1566 Wh in comparison to a ceiling fan which consumes 50 W or so. With this project, it is proposed to implement a Demand Response (DR) strategy using the thermal appliances in a building. It is a mini modular implementation of Smart Grid Systems. The goal is to monitor the usage patterns of ACs during different times of the day in relation to electricity demand at that time (which in turn leads to increase in electricity prices at that time). The key factor is to keep the user's comfort level intact and while keeping the temperature of the room in ideal operating range.

## Design and energy management of battery and supercapacitor based plug-in electric vehicles

**Advisor:** Dr. Iftikhar Ahmad Rana

Plug-in hybrid electric vehicles (PHEVs) are getting the attention of electric transportation market and the end users. They comprise of smart charging mechanism and a hybrid energy storage system (HESS). A topology for HESS based on battery/ultracapacitor (UC), coupled with two bi-directional DC-DC buck-boost converters can be considered. For controlled integrated charging and smooth execution of energy management algorithm, a unidirectional DC-DC converter can also be used. The mathematical model of the complete HESS with integrated charging unit for PHEV is needed to be designed. A nonlinear controller will be designed whose parameters would be tuned using some heuristic algorithm. Also an algorithm of high level control would be presented to switch between static and dynamic behaviors of the PHEV. The objective of the proposed control strategy is to adapt the unknown parameters of the system, deliver power for load well in time, output DC bus voltage regulation and smooth tracking of reference currents for the battery and UC with varying demands of the vehicle. The asymptotic stability of the system would be ensured by using Lyapunov stability theory. Finally, the energy management algorithm using the state of charge as decisive factor will be incorporated to maintain the stability of the system under

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varying load conditions. The performance of proposed controller would be compared with controllers proposed in the literature using MATLAB/Simulink. The performance of the system would be further verified by testing it on real-time hardware-in-loop setup as well as on a prototype PHEV which will also be designed.

## Design and Implementation of a Virtual Synchronous Generator (VSG)

**Advisor:** Dr.Farid Gul

Design a sine wave inverter along with an appropriate controller to render the inverter behave like a synchronous generator by adjusting the real and reactive power injection into the system.

Demonstrate the system through computer simulation and subsequently realize the system physically.

## Design of Artificial Pancreas and a Controller for Type 1 Diabetes Patients

**Advisor:** Dr.Iftikhar Ahmad Rana

Artificial pancreas enables closed loop automated control for blood glucose regulation in type 1 diabetic patients. A controller for regulation of blood glucose level has recently been proposed in the literature. In this research work, we will propose an advanced adaptive controller for integration in artificial pancreas. Controller design will be based on Extended Bergman's minimal model which represents the dynamics of blood glucose-insulin system of human body. Glucose effectiveness factor will be treated as an unknown parameter and its value will be adapted using Lyapunov based adaptive backstepping control approach. Effects of meal disturbance, physical non-linearities and sensor noise would also be considered in the controller design. A complete mathematical derivation of the proposed nonlinear controller would be described and simulation results would be presented using Matlab/Simulink environment. Results would indicate improvement in tracking response and overshoot/undershoot characteristics as compared to some recently developed techniques in literature. Proposed controller would assure dynamic stability against disturbances and deviations in human body parameters. Practical implementation of the proposed controller would result in better artificial pancreas. The performance of the system would be further verified by testing it on real-time hardware-in-loop setup as well as on a prototype Artificial Pancreas which will also be designed.



### Group Members:

Muhammad Ali Sajid  
Muhammad Abdul Mannan Khan  
Muhammad Khuzaima Saqib

## Mechanical Modelling and Design Characterization of a three phase Induction Motor

**Advisor:** Dr. Usman Khan

The Induction Motors acquire over 90% of the Industrial application related to automation. However, mostly the motors are imported and there are very limited to none local build of such motors being done in Pakistan. To fill this gap, this project aims to design a complete model of 3 Phase Induction Motor and to design the related electromagnetic characteristics.

## Photovoltaic cell, supercapacitor and battery based electric vehicles

**Advisor:** Dr. Iftikhar Ahmad Rana

A mathematical model for the photovoltaic cell, supercapacitor and battery based electric vehicles is to be designed. Then an advanced nonlinear controller is to be designed for the output voltage regulation of the DC bus. This control algorithm would be justified by the simulation results in MATLAB/Simulink, delfino based hardware in the loop simulations as well as on the prototype/actual electric vehicle: the prototype would also be made.

## Solar-based Dehydrating System for Food Preservation

**Advisor:** Dr. Hasan Arshad Nasir

Drying plays an important role in food preservation as it inhibits the growth of bacteria and increases the shelf life of food. In Pakistan, the drying method deals with the exposure of food in open sunlight. This traditional method is not only time taking but it also causes a lot of food wastage because of attacks from birds, other creatures, and rain. Secondly, bulks of food are exported to foreign countries just for drying purpose which increases transportation and packing cost, causing financial stress on the country. Hence, seeing the progress of this world and increasing large quantity of food being produced, it has become mandatory for us to design an efficient device that can be monitored artificially. This device will not only help in speeding up the drying process but will cut off the need for expensive and fuel consuming drying equipment that are operating on non-renewable sources. Furthermore, this device will reduce the electricity usage to a great extent, promoting renewable energy solutions to current practices. It will also preserve the quantity as well as quality of food in an excellent manner. Food dryer is a model based on temperature control mechanism that aims to dry the food both artificially and naturally. Drying process is faster and efficient through food dryer because the sun radiations are trapped inside it making it warmer than outside and consequently increase the speed of drying. It also lessens the risk of spoilage of food due to over drying and harm caused by solar radiations, birds, flies, pests, rain and dust. Resultantly, this all will cut off most of the dependency on natural process for drying and promotes sustainability.

### Group Members:

Abdul Moeed  
Huzaifah Bin Wasim

## A Scalable RISC-V based Multicore Processor

**Advisor:** Dr. Rehan Ahmed

Any realistic and practical application of a processor now requires power and speed which is delivered only with either an expensive chip with high clock speeds or making a multicore processor. Pakistan is in need of its own indigenously produced multicore processor to bolster complete control over the back end and secure functionality. Transforming an already existing indigenously designed RISC-V processor from the IC design Lab into a multicore system using open source tools is the main goal of this project.

## An Electroencephalography (EEG)-based Thought-to-Text Conversion System for Physically Disabled Persons

**Advisor:** Dr. Wajid Mumtaz

Every emotion that the human beings feel, and every thought that is conceived and every decision that is made is embedded in a complex circuitry of neurons inside the human scalp. The thoughts are thus simple encoding of the brain electrical signals, termed as the electroencephalography (EEG) signals. From this follows the natural consequence that these electrical signals can be decoded to convert our thoughts into text. This project aims at an implementation of such a Thought-to-Text Conversion system that can be used to construct a brain-computer interface (BCI). The BCI would provide a control mechanism solely through brain signals to code a physical response without any neuromuscular activity. This can help to bridge the world around us with the world inside us, providing a quantitative expression to the intangible thought-process inside the mind. More specifically, the Thought-to-Text Conversion system will be implemented using a Neural Network. A hybrid architecture will be used to capitalize the various advantages of CNNs, RNNs and other models. This model will decode brain signals, given EEG data as input, to find patterns to classify the different brain signals into corresponding alphabets and meaningful words. The NN will be trained on multiple open-sourced EEG data sets, with various optimization algorithms to achieve a high accuracy of the system and a desirable efficiency to match real-time applications. The model will then be tested in real time using real-time EEG data. The real-time EEG data will be obtained from volunteering participants using an EEG cap. The EEG cap will record brain signals and provide a text string to indicate the thought of the participant. This textual output can then be utilized in several ways to achieve various applications. It can be used in the medical context for rehabilitating paralysis and stroke patients suffering from neuromuscular paralysis. Moreover, it can be used in therapies and treatments of neurological disorders which patients are either unable or unwilling to express their true feelings to the medical practitioner, impeding a correct diagnosis and consequent effective treatment.



**Group Members:**

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Hira Najeeb

## An Explainable AI Based Clinical Decision Support System

**Advisor:** Dr. Ahmad Salman

A Clinical Decision Support System, CDSS, helps in improving Healthcare facilities by enhancing medical decisions. This is done by reminding/alerting doctors of the cause of a diagnosis or predicting a disease before it has occurred, and thus helping prevent it and an incorrect decision. Medical decisions are predicted based on previously stored Electronic Health Records, EMRs in a CDSS. An intelligent Clinical Decision Support System currently lacks the features of Explainability and Causability. When it comes to medical decisions it is very important to develop the trust between a Medical Practitioner and the CDSS generated decisions. After an unbelievable advancement in AI, humans are unable to understand the calculation process behind a neural network. In this project, we aim to implement Explainable Machine Learning methods to expand on the reason as to why a diagnosis was made, which can be understood and accepted by Medical Practitioners. Furthermore, in most of the cases only structured data is used to train and validate any deep learning model as a result when the model is tested on unseen data, it fails to predict disease efficiently. To add to that, unstructured data is not incorporated in most implementations, thus negating their practical usability. Therefore, we will be including unstructured data as well to extract information related to diagnoses which will help in increasing the efficiency, and the practicality of the model when tested on unseen data.

## AutoMotor: A Multimodal Multichannel DC Motor Controller

**Advisor:** Dr. Rehan Ahmed

The aim of this project is to develop a feature packed DC motor controller that can be employed for rapid prototyping and development of robotic, electric vehicle and automation applications. The device, named AutoMotor, is to have the following capabilities: Drive multiple brushless and brushed DC motors, integrated PID controller with analog and quadrature feedback interfaces, and multiple communication protocols such as servo PWM, UART and SPI. In addition, a GUI tool is to be developed that allows easy and intuitive configuration of the device, along with options for datalogging and retrieval.

**Group Members:**

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Ahmad Faizan Butt  
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## CabSafe: In-Cabin Monitoring of Vehicles using mm-Wave Radar

**Advisor:** Dr. Hammad M Cheema

In-cabin monitoring of personnel to classify age, posture for safe deployment of airbags is becoming essential in new vehicles. In addition, detection of children left behind in the car and subsequent notification is possible through radar. This project aims to develop a prototype for in-cabin monitoring system using mm-wave radar.

## Computer Vision Based Object Detection and Obstacle Avoidance for Visually Impaired People

**Advisor:** Dr. Ahmad Salman

The aim of this project is to design and manufacture a portable system for artificial vision. The system will perform real-time object classification through stereo cameras mounted on glasses' frame. Immediate obstacle avoidance will be performed using ultra-sonic sensors. The hardware will comprise battery operated Nvidia Jetson Nano. Deep learning will be used for object classification.

## Computer Vision Based Smartphone App for Supermarkets

**Advisor:** Dr. Ahmad Salman

In view of some real-world everyday problems, the idea of saving people's time at supermarkets is of importance. Hence, a smartphone app is to be designed to accomplish this. The smartphone will be mounted on the carts at the supermarket and the app will detect the items being put in the cart automatically using computer vision. The app will also make a bill for the customer and so the customers could pay the cashier at the checkout without needing to scan everything the person has bought. This will help reduce queues and make the process faster and efficient

**Group Members:**

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Haris Ali  
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**Group Members:**  
Hamza Bin Mazhar  
Saad Bin Muhammad

## COVID - An Automated System to Crowd Control

**Advisor:** Dr. Arbab Latif

The rampant coronavirus disease (COVID-19) has brought about a catastrophic global crisis, with the deadly and highly contagious virus spreading to a staggering 220 countries worldwide, with around 521 million cases and 6.26 million deaths having been reported worldwide as of 15 May 2022. The use of vaccinations has reduced the effect of this highly infectious disease, but with the constant threat and reports of new much more dangerous variants being reported around the world, strictly following SOPs is paramount to preventing the spread of this virus. Currently, it is an immense challenge to enforce SOP compliance in crowded areas such as hospitals, parks, markets, airports, cultural and religious points. Our system automizes this process and ensures that SOPs are followed with maximum efficacy. Our aim is to generate a system that utilizes OpenCV and Deep Learning to accomplish this, with the focus being on face mask detection, crowd counting and social distance monitoring. The system uses the YOLOv4-tiny algorithm which has been trained on a custom face mask dataset to be able to determine whether the people in observation are correctly wearing their face masks. The YOLOv4-tiny algorithm is also used in object detection to segregate humans from the background, using these detections, the system then measures the inter-personal distances between all people in observation to ensure a minimum safe distance of 6 feet is being maintained. The system would also keep a count of the total number of people detected within a particular area to ensure this number does not exceed a predefined safe amount determined based on the size and concurrent capacity of the area. Finally, the models are implemented on an NVIDIA Jetson Nano which is connected to a barrier that is used to ensure that SOP violators would not be allowed to enter a specific area or building. The system would be ideal for real-time use cases with all models running at 25-30 FPS due to the lightweight YOLOv4-tiny algorithm and the GPU capabilities of the NVIDIA Jetson Nano.

## EMG Signal-Driven Arm-Mounted Exoskeleton

**Advisor:** Dr. Ahmad Salman

The idea is to create an exoskeleton structure controlled by EMG signals for motor movement and mountable on arms. The EMG signals will be classified for several arm muscle movements and trigger the motor control. This has a sheer application for people with muscle degeneration and for industrial scale, heavy object lifting.

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## Dense Crowd Estimation

**Advisor:** Dr. Arbab Latif

Targeting on the significant ongoing research domain of dense crowd estimation that can be further extended to security and person recognition, dense crowd estimation is based on deep learning approaches to quantify individuals in a particular scene. After literature review, a comparative analysis was performed and documented for dominant models in the domain. Later, ASM model was developed using variable receptive fields to cater for many issues like occlusion and scale variations. Filters using variable receptive fields were used to process images individually and later their results were combined in a single density map that visually predicted the place of more population. Density map could be integrated to represent the number of individuals in a particular scene. While using Shanghai Tech as training data, which is most diverse and found very good for this project, ASM models were trained and tested. Later the image-based input was replaced via video-based input, and it was successfully working on the said task alongside providing a visual detail of crowd.

## Design of Efficient AI-coprocessor for Real-time Edge Inference

**Advisor:** Dr. Rehan Ahmed

This project aims to develop an Efficient AI-coprocessor for Real-time Edge Inference

## EV Battery Pack: Building 1 KW Battery pack using active Battery Management System

**Advisor:** Dr. Muhammad Shahzad Younis

Goal of this project is to develop a scaleable battery pack for small EVs with an active battery management system. Active Battery Management System will enable dynamic cell balancing, current voltage sensing, anomaly detection among other tasks. This is partially funded project from ASP Lab.

**Group Members:**  
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**Group Members:**

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Rafique  
Ali Abdul Rehman

## High-Speed Embedded Data Acquisition and Logging System

**Advisor:** Dr. Muhammad Imran

The technological boom in recent times has brought about a revolution. Data has become a key resource in all industries, especially in the field of controlling and monitoring. This project aims to create an embedded algorithm which can be used in unison with almost any system as a multi-channel, multi-protocol, high speed, data storage device. The current algorithm is based on UART communication for 4 channels, each running at a baud rate of 460800 bits/s, which is well above industrial standard. The project is to be used as a concept to display the possibility of improvement by using other communication protocols and faster data storage methods. The project uses STM32F429i Discovery Kit for demonstrating the algorithm, however it is a generic program, written in an abstraction layer so that any ARM Cortex-M4 device can run it. The project is designed to be reconfigurable, so that any user may decide the number of active channels and the baud rates of each channel. The project achieved complete loss-less reception on 4 channels, which was achieved with the help of DMA and RTOS, for performing time-critical operations.

## On the Edge Embedded Fault-Detection in Electro-mechanical Systems

**Advisor:** Dr. Usman Zabit

In this FYP, we have to develop an embedded system (based on an ARM Cortex MCU) that uses onboard machine learning to detect if the Electro-mechanical System has become faulty or not. This can be done by monitoring the vibration pattern of the machine via an accelerometer or a magnetic sensor. Any mechanical fault will result in change in vibration patterns of the machine which can then be detected and an alert is raised.

## Portable Chest X-Ray Classifier for quick TB Detection

**Advisor:** Dr. Usman Zabit

This is a follow-up project of last-year's FYP. The objective now is to deploy the developed machine learning based algorithm for TuberCulosis detection in a portable embedded system which runs the diagnostics by using a camera to capture the image of the x-ray in real-time.

**Group Members:**

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Safwan Ullah Khan  
Muhammad Bilal Elahi

**Group Members:**

Huzaifa Saleem  
Talha Khalid  
Mohammad Zain Farooq Gill

## Real Time Video Surveillance Anomaly Detection System on the Edge

**Advisor:** Dr. Rehan Ahmed

The aim of this project is to intelligently detect anomalous events from surveillance video, without human intervention. The main purpose of such systems is to provide timely detection of potentially hazardous behaviors thus allowing early actions to be taken to prevent or respond to events such as accidents or wrong-doing.

## Real-Time Unmasking of Masked Faces

**Advisor:** Dr. Muhammad Imran

In the current time, people frequently use masks to cover their face to avoid infection transmission or to prevent the harmful impact of environmental pollution. In many situations, it is desired that the identity of the persons may be known without the need to remove the mask (that can be potentially harmful as well). Different researchers have implemented unmasking of masked face using conventional image processing techniques as well as deep neural networks. However, these techniques have been explored using single images and high computational resources. Real-time applications of the same techniques using video data is required in many practical applications. FPGAs can be used to accelerate the processing of such image unmasking techniques on real time video data.

## Wheel Chair Simulator Game for Training People with Severe Disabilities

**Advisor:** Dr. Wajid Mumtaz

The purpose of this project is to develop an interactive game controlled by the brain signals. The software used to develop the game is available and open source. However, the project shall focus on the development of a test scenario that can be interfaced with the brain signals. The scenario will be tested and prepared for the wheel chair patients for their training purposes.

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## Dual Axis Intelligent PV tracker

**Advisor:** Mr. Nasir Mehmood

A solar tracker is to be designed to maximize PV output and operations using horizontal single-axis tracker, which will increase the performance of PV power plants by up to 30%, by following the sun throughout the day PV trackers maximise power generation. The tracker better match the grid demand profile, which peaks in the afternoon, and contribute to a smarter and more sustainable energy system.

Individual monitoring and control of each tracker is a cloud-based SCADA shows solar array status at a glance, in an intuitive manner Single tracker status can also be detected, including warnings and alerts, real time and historical data available.

## Laser based Nanometric Motion Measurement

**Advisor:** Dr. Usman Zabit

Non-uniform sampling principle is to be used to process a laser based sensor's signal such that nanometric motion of a remote target surface can be measured. The sensor is based on optical feedback based self-mixing interferometry principle. The task is to improve the performance reported in a paper published in IEEE Sensors Journal 2020. After proposing a solution, it can also be implemented and tested in hardware.

## Smart Traffic Control

**Advisor:** Dr. Ahmad Salman

We see all day the behaviour of traffic signals. Sometimes, more congested roads get equal time of green signal as compared less congested roads. This should be done automatically by observing the congestion of cars on a road via over-head camera. Similarly, if an ambulance appears with siren and protocol lights, it should be recognised and that road signal must get priority of getting green. The hardware will include Jetson Nano embedded system that will run ML algorithm for congestion recognition (by counting cars) and siren and ambulance classification (audio+visual). Based on the outcome, the signals will be controlled.

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## Fallback: Posture & Fall-Detection using mm-wave Radar

**Advisor:** Dr. Hammad M Cheema

With applications in elderly, nursing or normal homes, posture and fall detection using radar offers advantages over camera based approaches. The former can work in any lighting conditions and maintain privacy at the same time. This project involves use of mm-wave radar technology, embedded systems and machine learning to detect posture (sitting, lying, standing etc) and a falling event followed by notification to a caregiver or family member.

## Low-power Forest Monitoring System using LoRa-WAN

**Advisor:** Dr. Usman Zabit

This is a follow-up project of last-year's FYP. The objective now is to execute a machine learning based forest monitoring algorithm on a tiny , low-power Raspberry Pi Pico (which has just come out , and is based on ARM M0 dual processors consuming only a few mW) as well as to interface weather monitoring sensors with it. The network of nodes will be using LoRa-WAN technology.

**Group Members:**  
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## Deep learning based suggestive mechanism for Aquaponics

**Advisor:** Dr. Noshewan Shoaib

Traditional farming techniques require abundant agricultural land and water resources. This results in increased cost of land, transportation and labor. Aquaponics focuses on providing better crop production compared to traditional agricultural techniques, in a pollution-free and fuel-efficient manner. In this project, a deep learning based predictive model will be developed which will be able to predict the future values of water parameters in a close loop aquaponics setup. These values will then be used to generate suggestions for the user, regarding crop feasibility and future yields.

## Hybrid alternate energy system

**Advisor:** Mr. Shakeel Alvi

The overall idea behind this project is to use renewable energy sources to meet the energy demand and provide clean energy. Hybrid Alternate Energy System is made up of more than one source to produce the electricity and fulfill the load demand by smartly managing the power sources and load. In this Hybrid Alternate Energy System, Solar, Wind and Grid will be used as alternative sources. The main feature of this hybrid Alternate Energy System is to combine these renewable and traditional sources to make best use of them and get maximum efficiency higher than that could be get from single source. The renewable energy sources can be used in combination with battery. The main purpose of the battery is to provide backup when there is no renewable source of energy is available. The WAPDA can also be used as a source when no renewable energy source is available. Battery will be used when no other option (Solar, Wind, Grid) is available. There are two loads at the output of inverter and will be prioritized according to smart load management algorithm. The overall system is designed for 100Watts. Battery is used according to provide the backup for almost 45mins.

## Incremental Conductance Based Maximum Power Point Tracking for High Output Photovoltaics

**Advisor:** Dr. Usman Khan

The world is continuously striving to tap renewable sources of energy and solar energy presents a great deal of interest. To harness solar energy, photovoltaic (PV) systems are used, which typically have less efficiency, so it's advantageous to extract maximum power from the systems when possible.

The Maximum Power Transfer Theorem notes that when the load resistance equals the Thevenin resistance, maximum power is dissipated. We must run machines at their

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optimum power point in order to produce the best performance.

Maximum Power Point Tracking, or MPPT, is an electronic device that regulates the operation of photovoltaic (PV) modules to ensure that they produce the maximum amount of power possible.

Incremental conductance is a method to estimate the effect of a voltage shift by measuring incremental changes in PV array current and voltage. This method is faster than the perturb and observe method (P&O) at tracking changing conditions and does not generate power output oscillations.

## iPlug: Making your home modern and intelligent

**Advisor:** Mr. Ahmed Rasheed

An iPlug is a small adopter that can be plugged into a regular electrical wall outlet and converts ordinary devices and appliances in your home into “intelligent” ones such as air conditioning unit, water pump etc. You can take an ordinary electrical outlet in your home and put an iPlug in it. The physical outlet in your wall stays the same while the appliance/device that's connected to the iPlug now allows you to monitor and control the power supply to the appliance by conventionally/physically or wireless means through an app on your smartphone. Hence, such plugs make it easy to automate and control low/high power appliances and devices in your home. There are numerous smart plugs available in the market, but their high price (more than Rs. 3500) and difficult maintenance renders their adaptability and applicability in masses. Consequently, design and development of low-cost, reliable and stable smart plug will not only enhance its reach but will also enable power monitoring, control and management, so as to make appliances/devices in one's home automated, more efficient and tailored to one's personal preferences.

## Layer Fused 3D Printer

**Advisor:** Dr. Usman Khan

The 3D printing is one of the leading emerging technologies of Industry 4.0 . The use and implementation of additive manufacturing, in combination with other technologies, is producing an evolution in the industry towards an intelligent production where machines (autonomous, automatic and intelligent), systems and networks are able to exchange information and respond to the systems of production management. In addition, as a technology capable of turning a 3D design into a product without intervention, 3D printing has a fundamental role. Moreover, the need for expensive tools and fixtures is eliminated, reducing post-processing, material waste and human intervention. These are characteristics that define the industry of the future . In this project we will be working on the fabrication of LayerFused C201 3D Printer, which will have potential of working at industries like health, medicines, aerospace, robotics, automotive, education and other sectors as well.

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### Smart domestic Solar system

**Advisor:** Mr. Shakeel Alvi

An intelligent solar system which not only generates electricity and store energy , but also intelligently use it for domestic consumption.

### Design & Development of IoT Network for Aquaponics

**Advisor:** Dr. Noshewan Shoaib

Traditional farming techniques require abundant agricultural land and water resources. This results in increased cost of land, transportation and labor. Aquaponics focuses on providing organic crop production compared to traditional agricultural techniques, in a pollution-free and fuel-efficient manner. In this project, the students will design and develop IoT mesh network for the aquaponics farm located at SEECS. The students have to integrate several commercial sensors and motors via mesh node and send data to cloud via WiFi gateway. The data will be visualized in real time on aquaponics web-portal available at RIMMS.

### Design of an IoT based automated Aquaponics system to provide a sustainable farming solution in Pakistan

**Advisor:** Dr. Mohaira Ahmad

Aquaponics is the co-culture of fish and vegetables in a recirculating bio-filter based system. Since water is supplied to the vegetables from the bottom of the bio filter, evaporative losses are significantly reduced, allowing vegetables to be grown in a climate that cannot support conventionally grown vegetables. Moreover, the conversion of fish raised by the bio filters in forms of nitrogen suitable for the plant intake eliminates the need for the application of costly fertilizers. Aquaponics is an innovative organic production method which is well suited for use in developing countries relying on short supplies of water and sustainable production methods. \the project proposed here will be a domestic size Aquaponics system, which will be based on IoT sensors to monitor the nutrients levels in the water of fish tank and automatically providing the fish food in the water. IoT sensors will also be responsible for monitoring the water purification levels and nutrients in the water for plants. There will be temperature sensors in the fish tanks and water level monitoring will also be done and in order to maintain the water level automated system will fill the tank in case of drop in the water level. All of the data from the sensors will be transmitted in real time to an android module with a designed app. The app will be able to control the water levels, humidity, light in the fish tank and fish food.

**Group Members:**  
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### Forest Cover Change Detection using 3d Point Clouds on Embedded Platforms

**Advisor:** Dr. Faisal Shafait

Deep Neural Networks are computationally expensive computational machines. An emerging trend in this domain is to run these algorithms on stand-alone machines using FPGAs. Current research aims to further build on this idea and work on its applications

### Localization of Abnormalities in EEG Signals

**Advisor:** Dr. Faisal Shafait

Automatic analysis of EEGs provides a clinical decision support tool that can reduce time to diagnosis and assist clinicians in real-time monitoring applications. In this study, a high-performance automated EEG analysis system based on principles of deep learning is proposed which will localize the occurrence of abnormalities in EEG signal resulting in the medical practitioners to cut down on the long procedures of manually analyzing the EEG

### Hand Tremor Reduction Device

**Advisor:** Dr. Wajid Mumtaz

A wearable glove that minimizes hand tremors when worn by patients effected with Parkinsons, Essential tremors or any other disease with a similar underlying condition. The project aims to develop a mechanism that will counter hand vibrations using basic principles of inertia and newtons laws of motion. Ideally the glove will be able to accommodate different levels of vibratory movements according to the user's needs and severity of their condition. The main challenge that we face is integrating the essential parts in a compact, ergonomic and light weight design to provide the best possible results; allowing the user to live a normal life.

### Robot Policy using machine learning

**Advisor:** Dr. Wajid Mumtaz

There have been rapid advances in robotics over the past years. There has also been an explosion in the scope and variety of situations they have been used in. But designing a robot and having a control policy making it do in response to the environment is a completely different task. Machine learning is also a field that has shown lots of progressive and impressive results especially in the sub-field of deep learning in learning input-output relations for tasks, outperforming any classical technique. We are looking to use ML techniques to assist robots to perform their task based on current state and environment conditions.



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### Asthma Monitoring using IoT and Edge Technology

**Advisor:** Dr. Rafia Mumtaz

The main goal of this project is to detect the severity levels of Asthma Patients, and people suffering from seasonal allergies. This can be done by designing filters that detect sound of the patient and that sound can be used to classify the severity level and give us other insights. Sensors can also be used to detect the breathing level, heart rate etc. Using datasets of several patients, suitable machine learning models can be built and using edge computing, results can be displayed in real-time.

### Wheat Yield Prediction using Computer Vision

**Advisor:** Dr. Sajjad Hussain

This project will develop a fully autonomous mini drone that can be used for sensing applications. Project deliverables will be to design autonomous control of a mini-drone and develop an onboard intelligent model (ML, CV, Deep Learning) for a specific application. The application may include identification of humans in a building during a rescue operation (fire, earthquake, or other disasters) using thermal images, agriculture sensing using onboard cameras, video surveillance in a military environment etc.

**Group Members:**  
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### Laser self mixing interferometer based vibration detector

**Advisor:** Dr. Salman Abdul Ghafoor

Self-mixing Interferometry (SMI) is a well-known method to sense optical phase variation, similar to what is provided by any traditional laser interferometers but, different from them, without requiring any optical component external to the source. Indeed, the phase of the optical field returning from the target into the laser cavity is impressed on the amplitude (AM) and frequency (FM) modulation of the cavity field by the minute signal retroreflected by the target into the laser cavity. Working with semiconductor lasers, the AM component is easily detected by means of the monitor photodiode, usually provided by the manufacturer in the same package of the laser diode chip, mounted on its rear mirror.

### Anti-Theft System for Vehicles

**Advisor:** Dr. Salman Abdul Ghafoor

The project involves design and development of an anti-theft system. The main component involves a the design of a high current carrying relay that can be controlled remotely through GSM or some other suitable communication protocol. An application will be developed that controls when to open or close the relay for controlling the current passing through it. This relay will be fitted at a suitable point in the engine electric circuitry and will provide an additional security by controlling the engine start up.

### Macro Scale Molecular Communication System

**Advisor:** Dr. Hassaan Khaliq Qureshi

Molecular Communication is a communication system that is based upon the transfer of information using molecules as the primary means of propagation. It has received a lot of attention as a means of communication at the nano-scale level, allowing nano-machines to communicate with each other and interact with their environment. However, prototyping this at the nano-scale level poses many challenges. Our goal is to develop a macro scale model that is scalable and can be used to readily demonstrate molecular communication schemes.

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### A Bidirectional Single-Phase Vehicle to Grid (V2G) energy System

**Advisor:** Dr. Zubair Rehman

The need for the electric vehicles is increasing exponentially with the depletion of fossil fuels. The increase in the EVs has increased the demand of the power from the grid; this is where a vehicle to grid system comes to the rescue. It provides necessary services to the grid during the peak hours because of its dual “Load-Source” nature. A bidirectional single-phase vehicle to grid (V2G) system consists of DC/AC inverter and a full-bridge isolated DC/DC converter. The reduction in switching losses and the increase in efficiency of power flow is done by designing an optimized current controller for DC/AC converter. A phase-shift controllers introduced to the DC/DC controller provides the bidirectional operation and controls the charging and discharging modes of EV’s battery in soft switching mode. The system is demonstrated through MATLAB/Simulink and subsequently it can be realized physically. In addition to that, if time permits we can also introduce an alternative Solar Source to charge the EV and sell the power to the different loads apart from the public grid.

### Design and implementation of a switch-mode ac-dc power converter/rectifier.

**Advisor:** Dr. Farid Gul

Single phase/three phase line supply has to be rectified and stepped down to 50 Volts DC through a buck converter.

The output 50 V DC is required to be isolated from the input.

The output voltage has to be regulated through a feedback mechanism to keep output within the range  $50 \pm 1$  V when the out current is varied from 0 to 20 amperes.

### Electronic Load Controller

**Advisor:** Dr. Farid Gul

Synchronous machines are primarily used to generate electric power at hydro power stations. The rotational speed of the generator depends on two factors, the mechanical power of the water flow and the load connected with the generator. If any of these alter, the speed of the generator too alters causing an equivalent decrease or increase in its output voltage and frequency. For efficient and safe operation of electric appliances voltage level and frequency are required to be maintained within tolerable limits. Variation in load will cause variation in rotational speed of the generator and thus in electrical output voltage and frequency. Conventional hydro electric generators use speed governor and also excitation controller to regulate the speed, frequency and voltage generated and fed

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to the user loads. Since the cost of speed governor is high, Micro Hydro Systems do not use speed governors. However, the speed is governed indirectly by maintaining constant load on the generator and hence the turbine by using electronic circuits. Thus by using ELECTRONIC LOAD CONTROLLER (ELC) the load on the generator is maintained constant for a given water input. An ELC is a solid-state electronic device 2 designed to regulate output power of the generator used in the micro-hydropower system. Maintaining a near-constant load on the turbine, the generator generates a stable voltage and frequency for a given constant water input. ELCs react so fast to load changes that speed changes are not even noticeable unless a very large load is applied.

OBJECTIVES:

- (a) Carry out literature survey and develop thorough understanding of the various techniques employed to implement ELC.
- (b) Design and implement lab model of ELC.
- (c) Design and set up testing facility for demonstrating working of the ELC.
- (d) Demonstrate ability of the ELC to monitor and divert surplus power to the dummy loads thus maintaining constant load on the generator.

### Low Cost Smart Hybrid Inverter

**Advisor:** Dr. Rameez Hayat

Solar power is an alternative energy source to fulfill the increasing demand of energy. A hybrid inverter is a new generation of U.P.S for home consumption that provide power from three sources: solar, batteries, grid. The aim of this project is to design a low cost hybrid inverter that can smartly choose between different power sources.

### MPPT algorithm based Charge controller

**Advisor:** Dr. Hina Gohar Ali

It will be required designing of charge controller based on MPPT algorithm(maximum power point tracking) for Solar applications. MPPT algorithms are used for power extraction to operate the PV panel at maximum power in order to improve efficiency.

### Smart DC Microgrid

**Advisor:** Dr. Rameez Hayat

Conventional power plants such as heat power, nuclear power, etc., supposed to be responsible for wide-area transmission, pose grave challenges like pollution, transmission losses, and catastrophic safety concerns. With the ongoing energy crisis and the ever-increasing energy demand, there is a dire need for newer, cleaner, and sustainable energy resources. Renewable energy sources such as solar power, wind power, etc., are usually



small-scale, and their outputs are unstable. Such renewable energy sources are distributed, and the batteries are often equipped to fill in the temporal gap between generation and consumption. To cater for these needs, we have designed a DC Microgrid that will not only provide reliable renewable energy in abundance but will provide stable power and will also reduce transmission losses because of the absence of the reactive power while being environmentally clean and economically sustainable for masses. To ensure maximum efficiency in our system, Photovoltaic (PV) and Wind energy systems are operated at their maximum power point using perturb and observe algorithm (MPPT) while maintaining the load generation balance under varying load conditions using Sliding Mode Control (SMC).

### Solar Charge Controllers-MPPT vs. PWM

**Advisor:** Dr. Hina Gohar Ali

The non-renewable resources of energy are depleting with time. Meanwhile, the reliability of humans on electricity is multiplying with time. This implies the reliance upon the renewable resources of energy to meet the needs of electricity at homes, hotels, offices, and all around the world.

Among renewable energy resources, one of the important and major resource of energy is solar power. In order to utilize the readily available solar irradiance, Photovoltaic (PV) cells are used globally to capture the light energy and convert it in to electrical energy. This light energy can be stored in batteries to be used as a back up source at times of night or in cloudy conditions.

To control the charging of batteries “solar charge controllers” are connected between the solar panels and the batteries. We are comparing two solar charge controllers: PWM and MPPT.

PWM, works by pulling down the voltage level of the solar panel to that of the battery to ensure its proper charging.

MPPT regulates the current from the solar panel in such a way as to provide maximum power to the battery.

### Under-Frequency Load Shedding Philosophy - UFLS

**Advisor:** Dr. Ahmed Rasheed

An airborne wind turbine is a kite like device tethered to a generator for generating electricity. Winds at high altitudes are many times stronger and more consistent, as compared to near ground. Such systems can help solve our country’s energy crisis.

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### Breast Cancer Detection via Microwave Sensing Techniques

**Advisor:** Dr. Noshewan Shoaib

Breast cancer is one of the major health concerns in Pakistan. On one side, its awareness is very important while on the other side, its early detection is critical. In this context, this FYP will focus on early detection of breast cancer via microwave imaging techniques. The team will design & develop a wide-band (3-10 GHz) compact antenna system and integrate it with test system to acquire the measurements of a human tissue model that mimics a human breast. The anomalies in the measurements will be analyzed via microwave imaging.

### Design and development of an IC based RF Receiver for Wireless Applications

**Advisor:** Dr. Noshewan Shoaib

In this FYP, the students will design & develop an IC based RF Receiver for Wireless Applications at S-band. A superheterodyne receiver will be designed in which an RF frequency will be down converted to an intermediate frequency (IF). Appropriate biasing network and bandpass filters will also be designed to achieve the design goals. The students will take advantage of software packages, RF components and fabrication/testing facilities available at RIMMS. The project will also be helpful for the students to secure job placement opportunities in RF industry after graduation.

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## Machine Learning for Non-orthogonal Multiple Access in B5G Networks

**Advisor:** Dr. Syed Ali Hassan

The sixth-generation (6G) of wireless communication aims to fulfill extremely high data rate and ultra-low latency requirements while supporting massive connectivity for empowering the diverse paradigms of wireless communications. Nevertheless, despite the rapid evolution, the energy management of Internet-of-Things (IoT) devices is amongst the most crucial challenges hindering their large-scale deployment. Backscatter communications (BackCom), an energy harvesting technique, is a potential and viable contender for enabling the sustained operation of battery-constrained IoT devices. This approach involves the transmission of information by a backscatter node through passive reflection and encoding of an impinging continuous RF signal with its desired data. However, the short operational range and low data rates of contemporary BackCom systems render them inadequate to provide ubiquitous connectivity among the plethora of IoT devices. Moreover, there is a continuing shift towards the smart radio architecture in the deployed wireless networks. Thus, to enhance the coverage range and capacity, reconfigurable intelligent surfaces (RISs) can be incorporated into the existing BackCom systems. RISs employ passive reflective elements to adaptively configure the stochastic wireless environment in an economical and energy-efficient way. Furthermore, non-orthogonal multiple access (NOMA) can be exploited to improve the spectral efficiency of the BackCom systems.

## Machine Learning for Resource Allocation in mmWave and THz Networks

**Advisor:** Dr. Syed Ali Hassan

Beyond 5G networks require low latency, high throughput and high data rates while maintaining appreciable coverage. To achieve this, a wider bandwidth is required. Terahertz (THz) band can provide such large bandwidth; however, it is not as reliable as the sub 6 GHz band due to absorption effects. Hence, we need infrastructure level approaches such as heterogeneous networks (HetNet) that provide backwards compatibility to increase coverage and reliability. In this project, we consider a HetNet comprised of small base stations at THz and mmWave frequencies, and macro base station at sub-6 GHz frequency at different building densities based on multiple cities around the world. For quality of service (QoS) performance metrics, we take data rate coverage and power efficiency. Different system parameters are varied for six different locations to analyze the effectiveness of the proposed HetNet. Our results show that B5G networks are considerably more effective in environments with low building densities.

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## Automated Car Parking With Empty Slot Detection

**Advisor:** Mr. Yasir Iqbal

This system demonstrates a fully automated car parking system. For this purpose, we will use IR sensors along with motors, LCD display and microcontroller for controlling the system working. Our system will consist of an LCD display that is used to demonstrate as a parking gate entrance display. The system displays and guides to the empty slots to a new car arriving at the gate of parking area. If no parking space is available, the system does not open the gate and displays parking full. If slot is empty, system allows the car to enter the lot and displays and guides to the empty slots where user can park. To detect vehicle slot occupancy, the system uses IR sensors. Also system uses IR sensors to detect vehicles arriving at parking gates, to open the gates automatically on vehicle arrival. The microcontroller is used to facilitate the working of the entire system. The project will help the visitors to avoid the hassle of car parking and the time wastage due to the searching of an empty space.



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