

NANYANG

research programme



NRP 2023

Project Synopses

Nanyang Research Programme (NRP) is offered to JC1 and Year 5 students. It seeks to offer students with a keen interest in and aptitude for research the opportunity to engage in the process of intellectual inquiry by undertaking projects in a real research environment under the supervision of NTU faculty and researchers.

NRP Student Participants will undertake eight months of research activities from April to December, either individually or in a pair, culminating in the submission of a Research Paper in January of the following year and an Oral Presentation Assessment in late February/early March.

NRP Project List

Category	Project Code	Project Title
Engineering	CCEB01	Lateral flow assays for rapid detection of bacteria
	CCEB02	Assessing the Environmental Impacts of Green Solvents used in Pharmaceutical Industry
	CCEB03	Assessing the Environmental Impacts of Solvents used in Alternative Protein Production
	CCEB04	Process Simulation
	CCEB05	Reactor Simulation using Aspen HYSYS
	CEE01	Environmental degradation of plastic packaging
	CEE02	Osmosis-based membrane technology for water purification, desalination and renewable energy harvesting
	CEE03	A data-driven approach for the traffic resilience analysis in Singapore
	EEE01	Research and development of spectrum-adaptive light
	EEE02	Emissions from Rare-Earth Ions by the Energy Transfer from ZnO Nanocrystals Embedded in SiO ₂ Film
	EEE03	Power supply system for smart contact lens
	EEE04	Advanced Gallium Nitride High Electron Mobility Transistors (HEMTs) for High-Frequency Applications
	EEE05	Implement Environmental Sensor Under Internet of Things
	EEE06	Finding patterns in job advertisements and skill descriptions to perform mapping using text mining algorithms
	EEE07	Smart Car Sharing in On-Demand Mobility

Click on the respective 'Project Code' for the specific project synopsis.

Category	Project Code	Project Title
Engineering	EEE08	Structures and optimization of Perovskite solar cells
	EEE09	Application of deep learning algorithm for orthogonal frequency-division multiplexing systems
	EEE10	Deep learning based algorithm for frequency estimation from noisy signals
	EEE11	Performance study of DVB-T2 system using common simulation platform (CSP)
	EEE12	Performance study of rotated quadrature amplitude modulation (QAM) signals over fading channels
	EEE13	Art Creation Using AI
	NIE08	Can Artificial Intelligence automatically detect human activity: applications in tennis, badminton and teaching contexts
	NIE11	Designing an Artificial Intelligence and/or Robotics System for Potential Real-World Applications
	SBS01	Ex vivo Engineering of cellular surfaces, a transfection independent approach.
	SCSE01	Detection of Handwritten Mathematical Expressions via Deep Learning Approaches
	SCSE02	Text Localization and Recognition in The Wild

Click on the respective 'Project Code' for the specific project synopsis.

Category	Project Code	Project Title
Sciences	CCEB06	Development of new programmable RNA editing tools
	CCEB07	Development of new technologies for precision genome engineering
	LKCMed01	To examine the microflora in the water at Nanyang Lake
	MAE01	A Fast Way to Compute Matrix Multiplication
	NIE07	Particle Swarm Optimization
	SPMS01	Development of Nucleic Acid Therapeutics (NAT)

Click on the respective 'Project Code' for the specific project synopsis.

Category	Project Code	Project Title
Business, Humanities, Arts, and Social Sciences	NIE02	Reading Singapore Literature as Ecowriting
	NIE03	Family Relationships, Stress, and Child Emotional Development
	NIE04	The Neuroscience of Math Learning
	NIE05	Topics in Singapore English
	NIE06	Effects of Dark Chocolate Supplementation on Physiological Measures and Sprint Test Performance
	NIE09	Recall of In-Game Advertisements
	NIE10	Exploring the Role that Game-Based Worlds and Immersive Environments Potentially Play in Learning
	NIE12	Parent-Adolescent Relationships in the Digital Age: from a digital parenting perspective
	NIE13	Perceptions towards novel food among Singapore Consumers
	NIE14	Sense of Food Resiliency among Secondary/JC students in Singapore
	NIE15	Literary Theory and Modern Poetry
	SoH01	A Sociolinguistic Investigation of French, German, Italian and Spanish in Singapore Shop Signs
	SoH02	Arab philanthropies and how they influence the spread of Arabic Language on Singapore landmarks
	SSS01	Assessing Social Attributes of Faces

Click on the respective 'Project Code' for the specific project synopsis.

Engineering

School of Chemistry, Chemical Engineering and Biotechnology

Project Code CCEB01

Project Title Lateral flow assays for rapid detection of bacteria

Description This project is to use functional nanostructures such as signal-generating nanostructures and magnetic nanoparticles for the detection and separation of bacteria. Biocompatible nanostructures and iron oxide nanoparticles will be functionalized with a binding ligand with specific recognition to common bacteria found in infectious diseases and water and food contamination. Nanostructures such as gold nanoparticles will be primarily used for the optimization the surface chemistry because of the easily detected colorimetric or surface-enhanced optical properties. Different designs of magnetic structures will be examined for efficient bioseparation to improve the detection sensitivity of the lateral flow assays.

The project will explore the impact of design parameters of the test strip such as nanoparticle loading and assay flow for the specificity and sensitivity for representative Gram-positive and Gram-negative bacterial pathogens. The design of the test strip is similar to the antigen rapid test used for COVID-19 detection. The use of the test strip and optimized assay for real-life samples will also be investigated.

Offered As NRP Enrichment

Group Size Individual / Pair

Specific Knowledge No specific requirement. Understanding the basics of size dependent properties of nanomaterials and the design of biosensors for diagnostic application would be helpful.

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Engineering

School of Chemistry, Chemical Engineering and Biotechnology

Project Code CCEB02

Project Title Assessing the Environmental Impacts of Green Solvents used in Pharmaceutical Industry

Description The extensive use of organic solvents in the manufacturing of pharmaceuticals has led to many environmental issues including toxicity to human, ecosystem. In recent years, many researchers have touted the use of "Green solvents" which are more environmentally friendly, such as ionic liquid, deep eutectic solvent, etc.

In this project, you will be carrying out an investigation to determine the "greenest" solvent for pharmaceutical manufacturing among the made green solvent candidates. You will start the project by conducting a literature review on the latest developments in green solvents, and then carry out an environmental assessment by life cycle analysis to determine the "greenest" solvent.

This project requires the use of life cycle analysis software. This project does not involve laboratory experiments.

Offered As NRP Enrichment

Group Size Individual / Pair

Specific Knowledge High interest in chemistry

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Engineering

School of Chemistry, Chemical Engineering and Biotechnology

Project Code CCEB03

Project Title Assessing the Environmental Impacts of Solvents used in Alternative Protein Production

Description The extensive use of organic solvents in the manufacturing of plants-based proteins for extraction has led to many environmental issues including toxicity to human, ecosystem. In recent years, many researchers have touted the use of "Green solvents" which are more environmentally friendly, such as ionic liquid, deep eutectic solvent, etc.

In this project, you will be carrying out an investigation to determine the "greenest" solvent for pharmaceutical manufacturing among the made green solvent candidates. You will start the project by conducting a literature review on the latest developments in green solvents, and then carry out an environmental assessment by life cycle analysis to determine the "greenest" solvent.

This project requires the use of life cycle analysis software. This project does not involve laboratory experiments.

Offered As NRP Enrichment

Group Size Individual / Pair

Specific Knowledge High interest in chemistry

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Engineering

School of Chemistry, Chemical Engineering and Biotechnology

Project Code CCEB04

Project Title Process Simulation

Description Chemical engineering is not just about experiments, but also about playing with simulation software.

In this project, we shall look into various parts of the chemical plant. We shall employ a modelling platform - a user-friendly and exciting tool - to simulate and understand the operation of different operations of chemical plants.

The aim of this project is to give students a light appreciation of some core chemical engineering fundamentals with the aid of typically used simulation tools.

Offered As NRP Enrichment

Group Size Individual/Pair

Specific Knowledge Students will be doing modelling

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Engineering

School of Chemistry, Chemical Engineering and Biotechnology

Project Code CCEB05

Project Title Reactor Simulation

Description Chemical engineering is not just about experiments, but also about playing with simulation software.

In this project, we shall look into various parts of a chemical plant, especially the reactors. Reactors are the heart of the chemical process. We shall employ a modelling platform - a user-friendly and exciting tool - to simulate and understand the operation of different parts of chemical plants.

The broad aim of this project is to look at different types of reactors (catalytic reactors, Fluidized Bed reactors, etc.) with the aid of typically used simulation tools.

Offered As NRP Enrichment

Group Size Individual/Pair

Specific Knowledge Chemical Reactions

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Engineering

School of Civil & Environmental Engineering

Project Code CEE01

Project Title Environmental degradation of plastic packaging

Description Observe the environmental degradation behaviors of various plastic packaging materials. Different environments include seawater, fresh water, beach, sediment, compost, and landfill. Different packaging materials include conventional non-biodegradable plastics and novel biodegradable plastics.

Offered As NRP Enrichment

Group Size Individual / Pair

Specific Knowledge Wet lab skills.

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Project Code CEE02

Project Title Osmosis-based membrane technology for water purification, desalination and renewable energy harvesting

Description Osmosis is a natural process in which water molecules from a low concentration solution spontaneously permeate through a semi-permeable membrane into a high concentration solution. Based on the principle of osmosis, different types of membrane technology have been developed such as reverse osmosis (RO) and pressure-retarded osmosis (PRO).

In RO, a hydraulic pressure, which is higher than the osmotic pressure difference between the high concentration solution and the low concentration solution, is applied in the high concentration solution side. The applied hydraulic pressure can overcome the osmosis and push the water molecules in the high concentration solution reversely permeating through the membrane into the low concentration side. This process has been widely used in seawater desalination and water purification.

In PRO, the applied hydraulic pressure in the high concentration solution is lower than the osmotic pressure difference between the two solutions. Thus, it cannot overcome osmosis. The water molecules from the low concentration side still transport through the membrane to the high concentration side, but their permeation rate is retarded by the applied hydraulic pressure. PRO can be used to harvest the osmotic energy to generate electricity. Osmotic energy is a new type of renewable energy that originated from the mixing of two solutions with different salinities such as river water mixing with seawater at estuaries.

In practice, RO and PRO can be designed in different processes. In this project, various parameters on the performance of RO and PRO with different designs will be systematically investigated. These parameters include hydrodynamic conditions (e.g., applied hydraulic pressure and cross-flow velocity), feed solution conditions (e.g., salt concentration/salinity and composition) and membrane properties (e.g., water permeability, salt permeability, salt rejection, structural parameter, surface roughness, charge and hydrophilicity/hydrophobicity). The research will be conducted by lab experiments.

Students in this project are expected to gain a comprehensive understanding of the principles of osmosis-based membrane processes such as RO and PRO for various applications related to water and energy production. Students will also gain an understanding of the influence of various parameters on the performance of RO and PRO.

Offered As NRP Enrichment

Group Size Individual / Pair

Specific Knowledge Physics, chemistry, mathematics

Engineering

School of Civil & Environmental Engineering

Project Code CEE03

Project Title A data-driven approach for the traffic resilience analysis in Singapore

Description Transport plays a crucial role in the whole well-being of an urban society, while severe disasters (such as adverse weather events) or slight disturbances (such as vehicle breakdowns) can have a significant impact on the performance of the transport network. Especially, in a vulnerable network, the traffic jam of one node (e.g., an intersection) may spill over onto other nodes.

This project aims to analyze the characteristics of network-wide traffic congestion in Singapore, estimate and predict the traffic congestion spreading in the transport network. Advanced machine learning models will be applied for the data analytics. Programming and statistical analysis (in MATLAB or Python) will be performed for data cleaning/processing and modelling.

Offered As NRP Enrichment

Group Size Individual

Specific Knowledge Programming skills (in MATLAB or Python).

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Engineering

School of Electrical & Electronic Engineering

Project Code EEE01

Project Title Research and development of spectrum-adaptive light

Description Table lamps currently in the market could have warm or cold white light. Users will choose the one which is suitable for them. However, users typically do not know the scientific reasons for their choice. In fact, our eyes have evolved to adapt to sunlight, which changes from dawn to dusk with various light spectrums from warm to cool white light.

The project will do research on the sunlight spectrum throughout the day and build the table lamp with a tunable spectrum that can change the spectrum according to the user's need or following the sunlight so that users have a feeling of outdoor light.

Students will not only learn about the sunlight spectrum but also control the light with a simple microcontroller (Arduino) and coding.

Offered As NRP Enrichment

Group Size Individual / Pair

Specific Knowledge NIL

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Engineering

School of Electrical & Electronic Engineering

Project Code EEE02

Project Title Emissions from Rare-Earth Ions by the Energy Transfer from ZnO Nanocrystals Embedded in SiO₂ Film

Description Rare-Earth (RE) ions have been extensively used for various sources of light emissions. The emissions cover a wide range of spectrum, from visible to near infra-red, and hence they have been used for lighting, displays, optical amplifier and many others. The optical excitations of the RE ions, however, require a specific wavelength which is challenging and relatively expensive to have.

In this project, we will use semiconductor ZnO nanocrystals to act as sensitizers. The optical excitation of the ZnO nanocrystals is quite easy to have, as long as the photon energy is higher than the bandgap. The RE ions can in turn be excited by the energy transfer from the excited ZnO nanocrystals and give emissions when the RE ions relax to the ground states. The RE ions and the ZnO nanocrystals will be incorporated into SiO₂ films. The project involves the fabrication and characterization of the samples.

Offered As NRP Enrichment

Group Size Pair

Specific Knowledge Very good in Physics and Chemistry.

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Engineering

School of Electrical & Electronic Engineering

Project Code EEE03

Project Title Power supply system for smart contact lens

Description A smart contact lens is considered as one of next generation wearable electronic devices. Recently, many well-recognized companies including Google Inc. announced conceptual ideas of various usage of smart contact lens and research groups in academia started to report the demonstration of various components to be utilized in the smart contact lens such as sensors and actuators.

One of the challenges of the development of various components for smart contact lens is the harsh environment on eye ball meniscus of limited space and fluidic media. In addition, small energy capacity due to limited space requires energy efficient communication system to transfer the information to the user. Hence, the component of smart contact lens demands miniaturization as a form of thin film on the curved meniscus for user convenience, corrosion resistance in the fluidic media, and ultimate safety for eye protection.

In this study, a student will learn how to fabricate a micro battery on a contact lens device. The flexibility and proper electrochemical reaction of the fabricated micro battery will be studied. Finally, we will study how the electronic devices is integrated with a fabricated battery in a smart contact lens.

Offered As NRP Enrichment

Group Size Individual

Specific Knowledge NIL

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Project Code EEE04

Project Title Advanced Gallium Nitride High Electron Mobility Transistors (HEMTs) for High-Frequency Applications

Description Gallium Nitride (GaN) based High-Electron-Mobility Transistors (HEMTs) have been widely recognized as the preferred choice for next generation high-frequency and high-power device applications such as 5G/6G wireless communications, high power electronics, satellite communications and sensors etc. This is due to its inherent material properties such as wide band gap with high breakdown voltage and higher saturation velocity which enable it to operate at high-frequency, high-power, high-temperature and harsh environment.

In this project, the student will learn the basic operation, characterization techniques and analysis of HEMTs thus allow them to understand what it takes to achieve high-frequency and high performance GaN HEMTs for many key emerging applications.

Offered As NRP Enrichment

Group Size Individual

Specific Knowledge A-Level Physics and Mathematics

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Project Code EEE05

Project Title Implement Environmental Sensor Under Internet of Things

Description There has been very strong interest and attention in the past few years focused on the Internet of Things (IoT). The IoT refers to a network of physical objects embedded with electronics, software, sensors, and network connectivity, which enables these objects to collect and exchange data. It allows remote sensing and control across network infrastructure, creates opportunities for more direct integration between the physical world and computer-based systems, and results in improved efficiency, accuracy and economic benefit. [1]

One of the challenges in IoT technology is the provision of energy for sensing, electronics, communication, etc. It is important that the deployed devices are autonomous, that is, able to harness environmental energy and be self-sufficient so that there is no need to provide and replace batteries. Among the various sources of energy that can be harnessed from an indoor environment, light energy has been shown to be one of the most efficient and widely available.

In this project, the student will study and implement an environmental sensor to sense and transmit signals wirelessly to a host for real-time monitoring of the environmental parameter of interest. The scope will also include the building of a communication circuit and circuit for harnessing light energy to power the sensor and communication circuits, to realize a fully autonomous sensor.

1. https://en.wikipedia.org/wiki/Internet_of_Things

Offered As NRP Enrichment

Group Size Individual / Pair

Specific Knowledge No pre-requisites. Students should preferably have an interest in electronic engineering and in the study of renewable energy.

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Engineering

School of Electrical & Electronic Engineering

Project Code EEE06

Project Title Finding patterns in job advertisements and skill descriptions to perform mapping using text mining algorithms

Description It is challenging for a job seeker to identify the appropriate skillsets that a particular job scope requires, especially if he/she would like to know the area(s) to work on in order to secure a preferred job.

This project involves the use of natural language processing (NLP) techniques in a two-tier manner. First, given a dataset of job advertisements, simple semantic, syntactic, and frequency-based approaches will be utilized to detect common topics by grouping similar types of jobs. Next, given detailed skill descriptions across various industries obtained from the SkillsFuture Singapore (SSG) Framework webpage, words will be converted to embedding vectors and similarities between the grouping of topic-based job advertisements resulting from the first step and various skills will be computed.

The outcome of this automated mapping exercise would enable the identification of common skillsets that an employer is looking out for, hence enhancing an employee's application process.

Offered As NRP Enrichment

Group Size Individual

Specific Knowledge

- Preferably to have basic programming skills in Python, though it is not compulsory, as the student should be able to pick up the skill during the execution of the project.
- Good interest in machine learning and algorithms is expected.

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Project Code EEE07

Project Title Smart Car Sharing in On-Demand Mobility

Description Singapore has gone through a remarkable urbanisation process for the past several decades. So far, about 12% of the accessible land has been used for building traffic roads, and it is simply impossible to continuously expand the traffic network. To meet the ever-growing number of traffic demands, advanced traffic management techniques such as traffic signal control and flow management by road pricing have been developed and implemented. In addition, it is commonly believed that, by promoting ride sharing, the number of travel demands may be significantly reduced, which could ease the high pressure faced by LTA on pan-island traffic management. In this project the student will learn to model a simple traffic network and analyse the impact of ride sharing on travel demand reduction.

There are several objectives that the student is expected to meet:

- (1) To learn how to model a ride sharing problem as a mathematical programming problem.
- (2) To learn some simple optimisation techniques, in particular, the Lagrangian multiplier method. If time allows, some evolution algorithms may also be learned.
- (3) To apply relevant optimisation techniques to the ride sharing problem and solve it with right tools.
- (4) To develop a simple simulation based case study to illustrate the solution.

During this process, the student is expected to learn some basic concepts of linear programming, mixed integer linear programming, Simplex, Lagrangian relaxation and genetic algorithms. The simulation case study may be developed within a realistic traffic simulator PTV VISSIM, which also allows the student to understand some basic traffic management principles.

Offered As NRP Enrichment

Group Size Individual / Pair

Specific Knowledge For students who intend to develop their own optimisation algorithms, knowledge about calculating function derivatives may be needed. Nevertheless, this is not mandatory, as specific optimisation tools can be used to solve relevant optimisation problems.

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Engineering

School of Electrical & Electronic Engineering

Project Code EEE08

Project Title Structures and optimization of Perovskite solar cells

Description As a new type of high performance solar cells, Perovskite solar cells have attracted much interests since they were invented.

In this project, the student will study the solar cells and their operation. The student will learn the structures, the operation and characterization of the perovskite solar cells. Simulate the operation of the perovskite solar cell and optimize the solar cell structure to achieve the higher performance.

Offered As NRP Enrichment

Group Size Individual

Specific Knowledge Interests in physics and optoelectronic devices

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Engineering

School of Electrical & Electronic Engineering

Project Code EEE09

Project Title Application of deep learning algorithm for orthogonal frequency-division multiplexing systems

Description Recently, orthogonal frequency-division multiplexing (OFDM) techniques have been widely used for wireless communication systems, including the fifth generation (5G) cellular system. To further improve the performance and robustness of the OFDM systems, deep learning based algorithms have been introduced.

In this project, the student will study and design a deep learning based receiver for OFDM system in an end-to-end approach. We will explore the advantage of the deep learning model to recover the distorted signal. Moreover, the channel state information will not be required as compared with the traditional method.

Matlab and Python simulations will be conducted to study the performance of the proposed system.

Offered As NRP Enrichment

Group Size Individual

Specific Knowledge Preferably to have basic programming skills in Matlab and Python, though it is not compulsory, as the student should be able to pick up the skill during the execution of the project.

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Engineering

School of Electrical & Electronic Engineering

Project Code EEE10

Project Title Deep learning based algorithm for frequency estimation from noisy signals

Description Estimation of the frequency of a noisy modulated signal has been one of the main challenges in the field of signal processing and communications.

The objective of this project is to investigate the existing techniques for frequency estimation. Following that, a deep learning algorithm will be proposed to estimate the frequency of the modulated signal that is corrupted by Gaussian noise with the advantages of having higher accuracy and faster estimation time. Comparisons between existing frequency estimation methods and the proposed deep learning-based method will be carried out.

Matlab or Python programming will be used to study the performance of the proposed scheme.

Offered As NRP Enrichment

Group Size Individual

Specific Knowledge Preferably to have basic programming skills in Matlab and Python, though it is not compulsory, as the student should be able to pick up the skill during the execution of the project.

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Engineering

School of Electrical & Electronic Engineering

Project Code EEE11

Project Title Performance study of DVB-T2 system using common simulation platform (CSP)

Description Recently, the Terrestrial Digital Video Broadcast (DVB-T2) system has widely been deployed worldwide. It has been officially adopted as well in Singapore. The DVB-T2 system can provide much better signal quality.

The main focus of this project is on the decoding of the DVB-T2 signals under various channel conditions such as additive white Gaussian noise (AWGN) and fading channels. The performance of the algorithms will be studied and verified through the readily available common simulation platform (CSP).

Matlab simulation will be conducted to study its performance under different scenarios of channel conditions.

Offered As NRP Enrichment

Group Size Individual

Specific Knowledge Preferably to have basic programming skills in Matlab, though it is not compulsory, as the student should be able to pick up the skill during the execution of the project.

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Engineering

School of Electrical & Electronic Engineering

Project Code EEE12

Project Title Performance study of rotated quadrature amplitude modulation (QAM) signals over fading channels

Description Recently, rotated quadrature amplitude modulation (QAM) has been widely used in practical wireless systems. One of the important applications is the digital video broadcasting system in Singapore.

In this project, the objective is to study rotated QAM signals and simulate their bit-error rate (BER) performance over various fading channels. The performance of the algorithms will be analyzed and verified through the commonly available simulation programs from the common simulation platform (CSP).

Matlab programming will be used for BER simulation.

Offered As NRP Enrichment

Group Size Individual

Specific Knowledge Preferably to have basic programming skills in Matlab, though it is not compulsory, as the student should be able to pick up the skill during the execution of the project.

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Engineering

School of Electrical & Electronic Engineering

Project Code EEE13

Project Title Art Creation Using AI

Description In this project, the student(s) will explore various ways of creating art using artificial intelligence (AI).

First, the student(s) will use an existing tool for such a purpose. Next, the student(s) will be encouraged to improve on the existing tool and/or invent a new way to create art using artificial intelligence.

The student(s) is(are) not required to have prior knowledge on art or artificial intelligence before the project, but is(are) expected to learn the necessary knowledge during the project.

Offered As NRP Enrichment

Group Size Individual / Pair

Specific Knowledge None.

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Project Code NIE08

Project Title Can Artificial Intelligence automatically detect human activity: applications in tennis, badminton and teaching contexts

Description The main objective of this project is to apply artificial intelligence (AI) techniques in various contexts to develop objective measures about human activity. We propose to use computer vision and audio/speech analysis to automatically detect the activity performed by tennis players, badminton players or even by teachers in the classroom. Algorithm like OpenPose (<https://viso.ai/deep-learning/openpose/>) or Mediapipe will be used (<https://google.github.io/mediapipe/>).

For instance, we propose to characterise teaching behaviours through behavioural scripts that can be used to provide feedbacks to the teachers about what happens in the classroom, improve teaching, accelerate the teachers' training, and inform policies for the evolution of the classroom in Singapore. Similarly, we propose to train the algorithm to detect key strokes during a Tennis match (forehand, backhand, spin, etc...).

Using AI, mainly computer vision and speech recognition, the project will consist in training a computer with videos of actual classroom, tennis games and badminton games to automatically detect key teaching and playing behaviours and provide a simplified report about what happened during the lesson.

Offered As NRP Enrichment

Group Size Individual

Specific Knowledge No real prerequisite for this project, maybe some background in coding (like python or R) would facilitate the understanding of the work.

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Engineering

National Institute of Education

Project Code NIE11

Project Title Designing an Artificial Intelligence and/or Robotics System for Potential Real-World Applications

Description In this project, you will learn how to use open-source hardware (such as Arduino and Raspberry Pi), Artificial Intelligence (AI) computing platforms (such as NVIDIA Jetson) and sensors (such as cameras or microphones) to design and train an AI robot for a real-world application of your choice. You will be supported in your learning by a team of designers and developers who have extensive experience with open-source hardware and software.

Offered As NRP Enrichment

Group Size Individual / Pair

Specific Knowledge Interest in maker culture, artificial intelligence and robotics is a plus. Experience with programming languages such as Python will be helpful though not necessary.

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Engineering

School of Biological Sciences

Project Code SBS01

Project Title Ex vivo engineering of cellular surfaces, a transfection independent approach.

Description The identity of mammalian cells is commonly defined by their appearances or the types of surface receptors they present. In the meantime, cells also constantly undergo transformation and such that receptor expression profiles would morph into distinct profiles over time. Such surface receptor profiles are often considered as signatures of different cell types, and hallmarks of immune cell differentiation and development/activation stages. Harnessing this surface receptor distribution would be a convenient method to optimize cell based immuno-therapy. Engineered cells with more stable surface receptor profiles, or with the enhanced presentation of functional groups would possess the ideal activities to facilitate research and biomedical applications.

In this NRP project, the student(s) would work with an experienced research fellow to optimize and/or co-develop an engineering protocol to modify surface receptors, using enzymatic approaches.

Type of lab work involved:

1. Planning and molecular cloning.
2. Biochemistry
3. Structural Biology
4. Cell biology, immune activation assays.

No chemical hazard, no pathogens.

Offered As NRP Enrichment

Group Size Pair

Specific Knowledge This is a suitable beginner's biology project for High school students who have a firm Math background.

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Project Code SCSE01

Project Title Detection of Handwritten Mathematical Expressions via Deep Learning Approaches

Description Digitizing handwritten mathematical expressions has increased in usage in education, engineering, and science. Engineers, researchers and students may need to write many sophisticated mathematical expressions in their reports research papers, etc. in word or Latex. However, it is not an easy job. Having touch-screen devices, they can easily write down those expressions but the recognition is a challenge.

In this project, the student will study existing machine learning techniques of handwritten mathematical expression recognition. The student will propose an improvement or integrate the existing work into a system. The system will convert the handwritten mathematical expressions into the Latex format seamlessly. The work can be applied to an auto-assessment system for mathematics quizzes.

Offered As NRP Enrichment

Group Size Individual / Pair

Specific Knowledge

- Good at Mathematics and have some basic programming background
- Interested in AI and machine learning.

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Engineering

School of Computer Science and Engineering

Project Code SCSE02

Project Title Text Localization and Recognition in The Wild

Description Text detection is one of the challenging problems in visual navigation for autonomous vehicles.

In this project, students will make use of computer vision and machine learning techniques to detect the house number, road signs (textual signs) and any text information in the wild. The challenge of the project is that the font size, colour and style are not unique. Moreover, the background can be a dynamic scene.

The student will propose an improvement or develop an end-to-end system by using several existing works.

Offered As NRP Enrichment

Group Size Individual / Pair

Specific Knowledge

- Good at Mathematics and have some basic programming background
- Interested in AI and machine learning.

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Project Code CCEB06

Project Title Development of new programmable RNA editing tools

Description The ability to engineer genomes and transcriptomes and living cells lend itself to many biomedical and biotechnological applications. In recent years, CRISPR-Cas has emerged as a powerful system for genome and transcriptome engineering. Briefly, a Cas enzyme is recruited to a target site by a programmable guide RNA. In so doing, it can also bring along an effector domain to modulate the target gene.

Here, we are interested in developing new Cas13-based technologies to install A-to-I or C-to-U editing events in RNA transcripts. The tools developed may be used as a new therapeutic modality for well-defined genetic diseases and can also be utilized to study RNA editing in various biological contexts.

Offered As NRP Enrichment

Group Size Individual / Pair

Specific Knowledge Knowledge of molecular biology and genetics, past research experience on biology- or biomedical engineering-related topics, willingness to work hard.

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Sciences

School of Chemistry, Chemical Engineering and Biotechnology

Project Code CCEB07

Project Title Development of new technologies for precision genome engineering

Description An ability to introduce precise changes in the genome of a living cell lends itself to many biomedical and biotechnological applications. In recent years, CRISPR-Cas has emerged as a powerful system that enables us to engineer the genome of plants and animals, including humans. However, the efficiency of precision genome engineering remains low in many human cell types.

In this project, we will explore different strategies to enhance the ability of CRISPR-Cas to install any defined edit in the human genome. If successful, our work will bring CRISPR technologies one step closer to clinical reality as a new form of therapeutics.

Offered As NRP Enrichment

Group Size Individual / Pair

Specific Knowledge Some knowledge of molecular biology and genetics, some research experience on a biology- or biomedical engineering-related project, willingness to work hard.

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Project Code LKCMed01

Project Title To examine the microflora in the water at Nanyang Lake

Description This study aims to examine the microflora present in the freshwater at Nanyang Lake.

Why is it important to study?

It is important to have a holistic balance on the health of the environment – if this balance is disturbed, human health can be impacted - a discipline defined as One Health. The environment can be defined into soil, water, and air; and each matrix is inhabited with wildlife and microflora of a diverse range. Hence, factors that impact these wildlife and microflora, eg climatic changes, would have an indirect impact on human health.

Proposed study:

The study aims to determine water-borne microflora present in the freshwater at Nanyang Lake. The proposed study will require both field work to collect samples and laboratory work to process and identify samples.

Briefly, the students are required to draw out a map of the lake, access at least 2 sampling sites, sample the lake water, and bring the water back to the laboratory for processing. After the sample has been processed, the students would use state-of-the-art metagenomic methods to determine the presence of microorganisms in the water samples. If time permits, other methods such as microscopy and culturing methods can be used to complement the metagenomic methods.

The students would need to record the bacteria, viruses and fungi species present and work with their supervisor to make inferences on their importance to the ecosystem in the lake water, wildlife, as well as to human health.

What do the students learn?

At the end of the study, students would be equipped with general microbiology skills to identify water-borne microorganisms using state-of-the-art methods. In addition, the project would provide a chance for the students to apply critical thinking and develop their analytical skills in data analysis.

Offered As NRP Enrichment

Group Size Pair

Specific Knowledge General microbiological knowledge and skills would be helpful. Practical skills can be taught.

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Sciences

School of Mechanical & Aerospace Engineering

Project Code MAE01

Project Title A Fast Way to Compute Matrix Multiplication

Description Matrix multiplication is a mathematical operation that takes a pair of matrices to generate a new matrix.

Directly applying the mathematical definition of matrix multiplication gives an algorithm that takes nmp order of time to multiply an $n \times m$ matrix by an $m \times p$ matrix.

The goal of this project is to develop a fast way to compute matrix multiplication.

Offered As NRP Enrichment

Group Size Individual / Pair

Specific Knowledge Good at mathematics and Python programming

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Project Code NIE07

Project Title Particle Swarm Optimization

Description Particle Swarm Optimization is one popular class of computational methods employed by scientists, engineers, economists and many others to solve complex optimization problems in an efficient and generic manner.

This project invites enthusiastic individuals to acquire the PSO method, understand how and, perhaps why, it works, and apply it to real world context problems.

Offered As NRP Enrichment

Group Size Individual

Specific Knowledge

- Preferably, some knowledge of computer programming, especially Python, or Matlab.
- Simple pre-requisite knowledge of vectors, random events, etc.

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Sciences

School of Physical and Mathematical Sciences

Project Code SPMS01

Project Title Development of Nucleic Acid Therapeutics (NAT)

Description This project aims to develop targeted NAT. The research is in the areas of medicinal chemistry and chemical biology. The project involves chemical synthesis, human cell culture and characterization of gene knock down in human cells by NAT.

Offered As NRP Enrichment

Group Size Individual / Pair

Specific Knowledge NIL

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Project Code NIE02

Project Title Reading Singapore Literature as Ecowriting

Description Many important Singapore poets and fiction writers have written in response to the natural world or employed extensive natural symbolism in their literary work. However, there is minimal scholarship that analyses Singapore writing as ecowriting that foregrounds connections to the environment and to environmental histories.

Applicants are invited to research the broader social and historical contexts of 2-3 Singapore writers in conjunction with recent theories on ecological thinking, new materialism and other environmental challenges. Suggested writers for this project include but are not limited to: Lee Tzu Pheng, Edwin Thumboo, Arthur Yap, Wong May, Ho Poh Fun, Suchen Christine Lim, Minfong Ho, and Boey Kim Cheng.

Offered As NRP Enrichment

Group Size Individual

Specific Knowledge

- Student applicants should be proficient in the analysis of literary texts in the genres of poetry and/or fiction.
- Students should also possess the ability to construct complex responses towards literary texts in essay form.
- Students should be equipped with basic research skills in searching and accessing library databases, archives and associated materials.

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Project Code NIE03

Project Title Family Relationships, Stress, and Child Emotional Development

Description Students will have the opportunity to help with projects examining questions such as: How do children spend their time and is this important to their development? How does relationship quality impact children's memory? What is the impact of stress, including Covid-stress on family relationships?

Depending on interest and larger study needs, students may assist with questionnaire, eye-tracking, observational, or interview data collection and/or simple analysis.

Offered As NRP Enrichment

Group Size Individual / Pair

Specific Knowledge

- Good attitude
- Self-motivated
- Curious
- Willingness to learn
- Detail oriented
- Excel or programming knowledge is a plus but not a requirement
- Good people skills (especially if interested in working with participants)

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Project Code NIE04

Project Title The Neuroscience of Math Learning

Description The study of children who consistently attain low achievement scores in mathematics is challenging because there could be many underlying reasons for math struggles which include language difficulties, sensory processing deficits, inappropriate instructions, poor attitude towards mathematics, high anxiety or lack of home support. These factors may be exacerbated if the child has other learning difficulties such as attention deficit/hyperactivity disorder, global developmental delay, or other underlying deficits.

In this study, we use educational neuroscience methods to investigate if math performance can be predicted using behavioural and neurological data. We will also look into the design of neural-informed games to help students in their math learning.

Offered As NRP Enrichment

Group Size Individual / Pair

Specific Knowledge

- Good understanding of math curriculum
- Interest in educational neuroscience
- Experience with mathematics games
- Experience with statistical methods will be an advantage

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Project Code NIE05

Project Title Topics in Singapore English

Description For this project, we will work on natural language data from Colloquial Singapore English (otherwise known as Singlish). Data will either be collected through elicitation/production tasks, designed experiments, or from existing corpora/data sets. Singapore English is a contact variety of English with several unique features.

The specific aspect of Singapore English, as well as how the data is analysed will depend on the linguistic subfield of your choice: syntax (structure), semantics/pragmatics (meaning), or phonology/phonetics (sound). I am fine with adopting whatever linguistic framework you prefer to use.

Offered As NRP Enrichment

Group Size Individual / Pair

Specific Knowledge

- Native speaker of Singapore English, or have easy access to one.
- Good intuition, interest and curiosity in the way language is produced and processed.

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Project Code NIE06

Project Title Effects of Dark Chocolate Supplementation on Physiological Measures and Sprint Test Performance

Description Dark chocolate (DC) contains high levels of flavanols due to the high amount of epicatechin present. Flavanols are a group of compounds found in cocoa, tea, apples and many other plant-based food and beverages.

There is a growing body of evidence suggesting that a diet rich in flavanols can positively impact cardiovascular health (Rees, Dodd & Spencer, 2018). In addition, flavanols have been found to increase the availability and activity of nitric oxide, similar to the effects of beetroot juice supplementation (Patel, Brouner & Spendiff, 2015). An increase in nitric oxide has been proven to reduce oxygen cost during exercise and thus increase performance during submaximal exercise (Engler & Engler, 2004).

To date, research has been focused on the physical health benefits of dark chocolate consumption but limited research has been conducted on the use of dark chocolate supplementation to influence exercise performance (Patel, Brouner & Spendiff, 2015). Hence, the purpose of this study is to investigate the effects of dark chocolate on repeated sprinting and recovery during repeated anaerobic performance tests.

Offered As NRP Enrichment

Group Size Individual

Specific Knowledge

- 1) Communication skills
- 2) Attention to details
- 3) Adhere to protocols and guidelines for safe procedures in laboratory
- 4) Positive learning attitude and open mind
- 5) Basic understanding of human anatomy, circulatory and respiratory systems, effect of exercise and training

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Project Code NIE09

Project Title Recall of In-Game Advertisements

Description The aim of this research is to examine how the rate of recall of in-game advertisements is affected by different variables. Respondents will be tasked to play a console racing game in different environments. After the game, respondents will complete a survey to determine the recall rate for brands that appear in the game.

Offered As NRP Enrichment

Group Size Individual / Pair

Specific Knowledge

- 1) Have an interest in marketing theories and computer/mobile/console games
- 2) Able to recruit up to 30 respondents to play games
- 3) An interest in learning how to conduct statistical tests, e.g. t-tests

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Project Code NIE10

Project Title Exploring the Role that Game-Based Worlds and Immersive Environments Potentially Play in Learning

Description Since 2009, lesson units have been carried out in a number of schools with the aim of developing an understanding about how game-based worlds and immersive environments can be leveraged for learning; these lesson units have been used in a variety of subjects, such as Geography, Literature, and Design & Technology.

If you are interested in thinking about such worlds and environments, and/or about maker culture and open-source hardware/software, with a view to designing more authentic learning experiences, we welcome your participation in this project, which is likely to be sufficiently flexible to support your own particular areas of interest. You will be working as part of a team of designers and software developers as we help build teacher-capacity in curriculum and pedagogy.

Offered As NRP Enrichment

Group Size Individual / Pair

Specific Knowledge A healthy interest in collaborative learning. Interest in maker culture, game-design and learning through games is a plus.

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Project Code	NIE12
Project Title	Parent-Adolescent Relationships in the Digital Age: from a digital parenting perspective
Description	<p>The parent-adolescent relationship is one of the most important relationships in an adolescent's life.</p> <p>However, building and maintaining a healthy parent-adolescent relationship is difficult for both parents and adolescents. For example, adolescents strive for freedom and autonomy; in the meantime, parents want to protect their children while adolescents perceive that as being controlled.</p> <p>Moreover, the rapid developments in technologies bring parents and adolescents more challenges. For example, how parents regulate and monitor adolescents' engagement with social media. Concerns about this rapid digitalization of adolescents and parenting practices always appear in the research literature and popular press. A survey study conducted in the U.S. showed that two-thirds of parents thought parenting is harder today than 20 years ago, which might be due to the rapid diffusion of digital technologies, such as smartphones and social media (Auxier et al., 2020).</p> <p>Digital parenting practices are complex and multifaceted, including, but not limited to, monitoring of adolescent technology use, rule provision, enforcement, education and promotion of digital skills, navigation of online education, and the exploitation of online opportunities (Odgers, 2019). However, there is a research need to investigate the digital parenting practices of Singapore parents and how digital parenting practices impact parent-adolescent relationships.</p> <p>This proposed study aims to survey Singapore parents about how they regulate and manage children's engagement with the media (i.e., commonly used parenting practices, efficiency and usefulness of different practices, etc) as well as how digital media have become increasingly entangled with parenting practices, including emergent mediated parenting practices (i.e., sharing of children's pictures in social media, the increasing reliance on internet and apps for advice). In addition, the study plans to survey how adolescents and parents perceived the impacts of different digital parenting practices on parent-adolescent relationships.</p>
Offered As	NRP Enrichment
Group Size	Individual / Pair
Specific Knowledge	Prerequisite knowledge of using Google Forms or other similar online survey tools

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Project Code NIE13

Project Title Perceptions towards novel food among Singapore Consumers

Description Novel meat, such as plant based meat and lab grown meat, are becoming common in the market, online shopping platforms, and restaurants. However, such products are relatively new to consumers, especially lab grown meat, and we need to learn about consumer perception.

Plant based meat are products that resemble raw meat products, excluding traditional mock meat products such as mock duck or chicken found in vegetarian food stalls. These plant based meats are mainly made of plant products like beans and coconut oil.

Lab grown meat refers to meat cultured from a small sample of cells from a living animal with no animals harmed. While it is not available to everyone, it has gained attention through news articles.

Today, the overeating of meat is causing environmental issues because traditional meat releases greenhouse gases which can contribute to global warming.

The aim of this research is to investigate students' perceptions and preferences toward novel meats.

Offered As NRP Enrichment

Group Size Individual / Pair

Specific Knowledge NIL

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Project Code NIE14

Project Title Sense of Food Resiliency among Secondary/JC students in Singapore

Description The COVID-19 pandemic caused many unplanned disruptions of varying magnitudes, worldwide. With the growing global population reaching an estimated 9 billion in 2050, inflation in food costs and decreased food supplies contribute to the decline and urgency in tackling food security.

In Singapore, 90 percent of our food supplies are imported. The government's Food Resilience (FR) mitigation measures included stockpiling, diversification of food sources and providing funds to support and boost production supplies by local high-tech farmers at the national level². However, in communities and households, Household FR is defined as a household's ability to withstand stresses in disruptions in food availability often caused by multiple factors such as sudden reductions in food supplies, surges in food prices or massive food contamination.

Recent spates of panic buying to stock up both essential and non-essential supplies which led to empty supermarket shelves; are tale-tale indicators of low household FR which underpinned an insufficient comprehension about the mitigation efforts to assure and prevent panic, massive hoarding.

Leveraging on the current situation, it is important to initiate a national initiative to educate and promote greater awareness towards building household FR as a means to cope with such an unplanned crisis and declining food supplies.

The aim of this project is to measure the level of awareness and preparedness of teenagers in Singapore in handling potential food crises.

Offered As NRP Enrichment

Group Size Individual / Pair

Specific Knowledge NIL

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Project Code NIE15

Project Title Literary Theory and Modern Poetry

Description Literary theory represents a prescient and exciting framework through which to explore modern themes and ideas that poets reflect in their work.

This research project aims to explore the pertinence of philosophical constructs to modern poetry (from 1900 to the present day). The student will choose a school /branch of literary and critical theory (structuralism, poststructuralism, psychoanalysis etc) and employ its methods to analyze and understand the work of a modern or contemporary poet.

This project will provide the student with the opportunity to engage in interdisciplinary work, as we will engage in both theoretical exploration and the close analysis of poetry and poetic movements in the 20th and 21st centuries.

Offered As NRP Enrichment

Group Size Individual / Pair

Specific Knowledge A strong background in Literature at the junior college/IP level is required.

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Project Code SoH01

Project Title A Sociolinguistic Investigation of French, German, Italian and Spanish in Singapore Shop Signs

Description This study is the first step in investigating the recurrent forms and patterns of French, German, Italian and Spanish as used in commercial shop signs across different business sectors in Singapore. It seeks to uncover the motivations behind the use of French, German, Italian and Spanish here via surveys.

Apart from the four official languages and their various spoken dialects, Singapore is host to a variety of other minority languages (Gordon 2005). French, German, Italian and Spanish are other cases in point. Apart from its economic value, the popularity of French, German, Italian and Spanish seems to be due to its positive associations with high culture, haute couture and elegant lifestyle. These associations appear to be increasingly exploited in commercial signs across the island.

Offered As NRP Enrichment

Group Size Pair

Specific Knowledge Interest in European languages.

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Project Code SoH02

Project Title Arab philanthropies and how they influence the spread of Arabic Language on Singapore landmarks

Description Alkaff Mansion, Aljunied MRT station, Bussorah Street - what do they have in common?

In ancient Singapore, Arab philanthropists played a fundamental role in turning a sleepy, fishermen's island into one of the most bustling trade hubs in Southeast Asia. These individuals, such as Syed Omar Aljunied, were wealthy merchants and philanthropists who arrived in Singapore during a time when new opportunities for trade abound in the newly set up Singapore. Their contributions were monumental as they had played a part in the development of key infrastructures in Singapore. How has their influence pervaded the Singaporean landscape, especially in the names of streets and landmarks? How have these names evolved or changed over the years?

This study seeks to understand how significant these philanthropists were such that their names have been eternalized in Singapore's landmarks.

Offered As NRP Enrichment

Group Size Pair

Specific Knowledge NIL

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Project Code SSS01

Project Title Assessing Social Attributes of Faces

Description We tend to make inferences about a person's traits or attributes based on the appearance of the face. For example, we judge trustworthiness, attractiveness, dominance or threats, based on the face images, though the accuracy of such judgment is under debate.

It has been shown that our judgment of trustworthiness can be built within the first 100 ms after seeing the face. There have been extensive studies evaluating such social dimensions of faces. However, there are still open questions remaining to be answered. For example, what are the most important factors in assessing facial attributes? Are there associations among these different attributes? How does the previous exposure to faces of similar or different attributes affect our judgment of subsequently presented faces? Such as, does a happy face appear more trustworthy than a neutral or sad face?

We will use online surveys and/or psychophysical experiments to address these questions.

Offered As NRP Enrichment

Group Size Individual / Pair

Specific Knowledge Good at math and writing in English.

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