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Public Private Partnership (PPP) programme

New approach towards Private Sector on Research & Development

"To solicit co-operation of the private sector in the enhancement of research relating to science and technology" being one of the main three objectives of the NRC, the Public Private Partnership (PPP) programme is initiated in year 2012, even prior to the establishment of the NRC as a Statutory Board through the Act No. 11 of 2016.

It is a known fact that R&D can effectively play a vital role in contributing to the economic development and wellbeing of the society. NRC, therefore explored a stronger mechanism to cater the research needs of the private sector through its PPP programme. This programme, which was in operation so far was formulated for public sector to find a private sector partner and work with the private sector with equal sharing of funding 50:50 (NRC: private sector partner). The private sector was expected to commercialize the final product of the research along with the benefit sharing as per the legal agreement of the NRC.

To make the PPP programme more effective and to derive economic benefits in year 2023, NRC shifted away from its traditionally practiced mechanism, to reach the public sector first. The research requirement of the private sector was formally sought with details on the direct economic benefit to the nation. Thereafter, the public sector and private sector linkage was created. In this manner the public and private sector will work together, and the expected research results should be produced as per the private sector targets, so that commercialization can take place in a speedy manner. The valuable contribution from the PPP Committee

Members of the NRC and the Council Members paved the way to strengthen the PPP programme of the NRC.

The background for changing the PPP programme resulted in due to the Networking Fora organized by the Ministry of Industries, where the Ministry had created a platform for the researchers to showcase their products to the industries. These events enabled to successfully link the public sector with the private sector for commercializing the research products. These fora clearly revealed that, the end-product of a research is taken up by the private sectors only if it meets their requirement for commercialization, such as availability of the raw materials, a market (local or foreign or both) and the net profit etc.



The NRC is very keen on contributing strongly to economy through R&D, thorough the PPP programme where research can result in adequate returns on investment. However, the NRC will not be restricting its funding to the PPP programme, but also will continue the other research funding programmes such as the Investigator Driven Grants, which we hope to advertise next year. The NRC believes that such research should also be continued, and therefore, we will continue to support strengthening the scientific community through the research projects that train the future generation of scientists for our nation.

Some Highlights of Achievements of the NRC Research Projects

Highlights of achievements of a few research projects are presented in each Newsletter, we will present to the reader a few more outputs of the research projects funded by the NRC.

Revolutionizing Elderly Care: Human-Like Interaction in Intelligent Robotic Wheelchair

Achievements in Investigator Driven Research Projects NRC Grant No: IDG 17-069



Navigation of wheelchair by voice and gesture-based commands.

Introduction

The world faces a significant rise in the elderly population, resulting in a growing need for caregiving assistance. To bridge the widening caregiver gap, the development of devices that support independent living is crucial. The intelligent assistive robotic systems offer a solution for enhancing the elderly's quality of life. One primary challenge hindering the elderly and disabled individuals' independence is the mobility decline. Consequently, robotic wheelchairs are being designe

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-d to aid mobility, some even equipped with manipulators for object handling. Although existing robotic wheelchairs typically rely on joystick controls, the elderly and disabled individuals prefer intuitive, user-friendly interfaces that foster natural interaction. Despite progress, current automated wheelchair systems require further enhancements to meet the user needs.

Voice communication is widely used by humans, making it vital for intelligent wheelchairs to understand natural language voice commands, enhancing user satisfaction. For instance, users can direct the wheelchair with commands like "go to the kitchen" or "fetch the large glass" instead of using a joystick. Developing these interfaces is complex due to language uncertainties. A method for navigating automated wheelchairs via natural language has been explored but struggles with quantifying uncertainty. Incorporating nonverbal cues like gestures with voice may improve understanding, although methods designed for mobile robots may not suit intelligent wheelchairs due to differing operational contexts.

Therefore, the intelligent robotic wheelchair can be controlled by both voice and gesture-based commands. Furthermore, the intelligent robotic wheelchair will be equipped with a robotic manipulator for pick and place tasks, a laser scanner for perceiving the environment, and user-friendly control interfaces such as natural voice and gestures. This will ultimately enhance the rapport between human users and the assistive robotic aid in order to improve living standards of the elderly and disabled people.

Outputs

Wheelchair with intelligent systems for human like interactive capabilities including voice and gestures is available as the output.

Outcomes

This research further focuses on creating a human-like interactive intelligent wheelchair, combining vocal and hand gesture commands. An existing power wheelchair has already been upgraded with sensors and algorithms.



Navigation gestures: (a) Go forward, (b) Stop, (c) Go backward, (d) Hard leff, (e) Hard right, (f) slightly left, (g) Slightly right, (h) Turn around, (i) Slow down, (j) Go faster, (k) Turn off, and (l) Turn on.

Multimodal vocal-hand gestures encompass deictic, redundant, and unintentional gestures, enrich vocal commands, enhancing their meanings. Unlike prior systems, which mainly used predefined pointing gestures for reducing uncertainties, this study embraces various deictic gestures and uncertainties (like distance) developing a versatile system. Furthermore, a novel approach filters unintentional characteristics in multimodal vocal-hand gestures. It includes a hand gesture identification system that compensates for elderly hand tremors and extracts partial gesture information for broader usage. The intelligent wheelchair can navigate according to the user vocal and gestural commands, displaying situational awareness.

Way forward

Currently, the research results are being used in the ongoing development of the wheelchair. Additionally, the handling of objects on the wheelchair tray by an attached manipulator is in the development process. The initial stage of the project was funded by the NRC. The extension of the project is being conducted at the Intelligent Service Robotics Group at the Department of Electrical Engineering, with the support of the Centre for Advanced Robotics and the University of Moratuwa.

Prof. Ruwan Gopura Department of Mechanical Engineering University of Moratuwa



Prof. Buddhika Jayasekara Department of Electrical Engineering University of Moratuwa



Origin of Igneous Rocks and their Implications on the Petroleum System of the Mannar Basin, offshore Sri Lanka

Achievements in Investigator Driven Research Projects NRC Grant No: IDG 17-028

The Gulf of Mannar Basin, a failed rift is found immediatly the south of the Adam's Bridge between the northwest of Sri Lanka and the southeast of India. It has been formed due to multiphase breakup of the Gondwana. The Sri Lankan sector of the Gulf of Mannar Basin is referred to as the Mannar Basin, which extends over 45000 km2, in Sri Lankan waters. The sediment in the basin ranges 4-16 km. Hydrocarbon exploration in this basin started in 1981. In 2011, three hydrocarbon exploration wells were drilled in the northern part basin by a company named Cairn Lanka (Pvt.) Ltd. Two of those wells, named Dorado and Barracuda natural gas deposits. This discovery proved the existence of an active petroleum system in the Gulf of Mannar for the first time. The Barracuda well penetrated about 700m igneous rocks crystalized around 62 Ma ago between 3500 -4200 m below mean sea-level. Igneous rocks are interbedded with Maastrichtian sediments. The exact origin of igneous rocks and their impacts on the petroleum system in the Mannar Basin was little known. Hence, the aim of the research was to understand the origin of igneous rocks and their relation to Geological history of the Mannar Basin and their impact on petroleum system of the Mannar basin. Igneous rock cutting samples from the Barracuda well were collected from Petroleum Resource Development Secretariat (PRDS). Fifty-five (55) petrographic thin sections were prepared.



Fig. 1. The Mannar basin and the locations of Dorado and Barracuda wells

21 igneous rock cutting samples were analyzed for trace, major and Rare Earth Elements (REE). Three samples were analyzed for Sr- Nd isotopes.

Outputs

The results of the research were published in Island Arc Journal, which has 1.5 impact factor. In addition, the findings were presented at the 36th and the 37th annual technical sessions of the Geological Society of Sri Lanka in 2020 and 2021, respectively. The project also set up a Petroleum Geosciences laboratory having data room equipped with computer workstation for basin and petroleum system modelling and seismic data interpretation at Department of Oceanography and Marine Geology, Faculty of Fisheries and Marine Sciences & Technology, University of Ruhuna, Matara. The research gave rise to gather a rare set of basalt samples from the Mannar Basin and petrographic thin sections made from them.

Outcomes

The result of the research proves that the igneous rock in the Mannar Basin is continental flood basalts crystalised around 62 Ma, just 3.5 Ma after the main Deccan eruption. The Barracuda volcanism suggests coeval rifting between Seychelles-India and India-Sri Lanka. Thus, this study suggested simultaneous rifting between Seychelles-India and India-Sri Lanka. Further it showed that large plate reorganizations that took place during this time in the Indian Ocean have likely caused consequent passive rifting in the Mannar Basin. Igneous rocks seem to a minimum impact on the maturation or over maturation of potential source rocks in the Mannar Basin. The Petroleum Geosciences laboratory is contributing to undergraduate research and teaching in the Department of Oceanography and Marine Geology. This research also paved the way for starting a strong research collaboration with the PRDS and the Sabaragamuwa University of Sri Lanka.

Dr. Upul Premarathne Department of Oceanography and Marine Geology Faculty of Fisheries and Marine Sciences & Technology University of Ruhuna





Fig. 2. Comparison of Mannar samples with Continental Flood Basalts (CFBs) from Deccan Traps and Madagascar.

Way forward

Only some of the data and interpretations have been published. At present, another manuscript is being prepared while more data await interpretation. The results of new interpretation will hopefully expand our understanding of the Mannar Basin, its petroleum system and the geological history of the southern part of the Indian Plates after its collision with the Eurasian plate in in the early Eocene.

Acknowledgment

Petroleum Development Authority of Sri Lanka (PDASL) is thankfully acknowledged for providing samples and other relevant data for this research.

Seed biological traits of selected rainforest species from Sri Lanka: Towards conservation of biodiversity

Achievements in Investigator Driven Research Grants NRC Grant No: 17-095

Introduction

Tropical rainforests are among the most biodiverse and charismatic forest ecosystems with higher endemism and more rare species than most other ecosystems. Yet, the loss of biodiversity is one of the most remarkable environmental problems encountered by these forests. Restoration of the degraded forests is vital to ensure their existence and safeguard ecosystem services provided by them for the future. Ex-situ conservation and ecological restoration have been identified as important elements in biodiversity conservation at both regional and global scales (Li and Pritchard, 2009; Wyse et al., 2018). The successful implementation of cost-effective conservation strategies requires knowledge on seed biology, since seeds play a critical role in angiosperm regeneration (Kildisheva et al., 2020). Techniques of seed collection, determination of germination requirements of seeds, storage behaviour, dormancy and dormancy alleviation are some of the significant seed biological information required to plan successful conservation projects (Miller et al., 2017). However, lack of knowledge on seed biology is a significant impediment to the effective conservation of these tropical rainforest species. This research was conducted to gather information on seed dormancy, seed germination, seed storage behaviour and other seed biological traits of 56 plant species in tropical lowland rainforests of Sri Lanka.

Outputs

A dormancy profile for tropical lowland rainforests was created using seed dormancy and germination

behaviour data. According to the study, 63.7% of the species produced non-dormant seeds while 23.6, 9, 7.2 and 1.8% were producing morphophysiologically, physiologically, morphologically and physically dormant seeds, respectively.



Figure 2. Seed dormancy profile of tropical rainforest species in Sri Lanka. MD, morphological dormancy, MPD, morphophysiological dormancy; ND, nondormancy; PD, physiological dormancy; PY, physical dormancy.

Among the studied species, 32 species were identified as non-dormant (57% of the total species), while 24 species (43%) were dormant. Dormant species included 1 physically dormant species, 5 morphologically dormant species, 8 physiologically dormant species and 10 morphophysiologically dormant species.

The seed storage behaviour profile was constructed for the tropical lowland rainforests in Sri Lanka. Fifty-three percent of the species studied produced desiccation-sensitive seeds, while the other 47% produced desiccation-tolerant seeds. A higher percentage of tree species recorded desiccation-sensitive seed storage behaviour, while most of the shrubs, herbs and lianas recorded desiccation-tolerant behaviour. A significant difference between the proportions of the number of desiccation-sensitive species/ number of desiccation-tolerant species among different strata was observed (~ 2=215.6, P<0.001).

Storability at different temperatures of seeds of ten of the above species was studied. Of the five species that were stored for a period of 12 months, two species (40%) showed decreased germination after storage. This result suggests these species do not tolerate storage for long periods of time however, they survived during short-term storage (6 months). In this study, seeds of desiccation-sensitive species could be stored only for a very short period (~ 2 months).



Figure 2. Germinating seeds and seedlings of Mesua ferrea

Outcomes

The dormancy profile constructed for the tropical rainforests in Sri Lanka provides important information on the germination ecology of trees, shrubs, herbs, and lawns, which is crucial in describing the ecosystem dynamics. Alleviating dormancy is critical in restoration programmes to accelerate seedling emergence during seed sowing. Understanding this concept in restoration planning can help to determine the most suitable method for the propagation of the concerned species and to design successful seed-sowing strategies. Identifying the seed storage behaviour category is an essential step to deciding appropriate conditions to store seeds for conservation projects. Our data suggest that ex-situ conservation is possible for many species with desiccation-tolerant storage behaviour in the tropical lowland rainforests.

Way forward

In this study application of conventional seed banking techniques was not successful with desiccation-sensitive species. Hence the application of cryopreservation of seeds would be valuable as a potential strategy for long-term storage of desiccation-sensitive species. The data gathered must be disseminated to the relevant parties through appropriate means, Mini seed storage bank could be established to conserve seeds of endangered species based on the information gathered from this study.

Prof. K.M.G. Gehan Jayasuriya Professor in Botany Department of Botany Faculty of Science University of Peradeniya



Modelling and description of relativistic compact stars using Einstein's field equations Achievements in Investigator Driven Research Grants NRC Grant No: 18-077

Introduction

There has been a substantial effort on experimental searches for strangelets at leading laboratories and these terrestrial experiments are being complemented by observational searches for neutron stars and quark stars. Experimental observations of radio timing measurements such as a strong Shapiro delay signature in the binary millisecond pulsar PSR J1614-2230 and of the three post-Keplerian effects in the binary pulsar PSR J1903+0327 suggest that the densities of these compact stars exceed by far the ground state density of atomic nuclei, $\rho_s \approx 2.7 \times 10^{-14}$ g cm⁽⁻³⁾ that could eventually appear in the form of hyperons, a Bose-condensate of pions (or kaons), or deconfined quark matter. The high densities in the interior of compact stars, combined with the physics of the strong interaction,

involving a rich spectrum of particles and attractive interaction channels, lead to various interesting condensates under extreme conditions that include various superfluid and superconducting phases. Einstein's field equations in general relativity are useful to model such highly gravitating stars with extraordinary states of matter.

Exact models of Einstein's field equations, for spherically symmetric gravitational fields in static manifolds, are necessary to describe the interior matter of a compact stellar object in relativistic astrophysics where the gravitational field is strong. Spherically symmetric models are physically significant and are extensively utilized in a variety of applications; for example, the collapse of a star can be accurately modelled by a spherically symmetric gravitational field. In general, the matter inside the compact astrophysical object satisfies the barotropic equation of state (pressure as a function of density) and depending on the composition of matter inside the star various types of equations of state have been considered to model with Einstein's field equations. In modelling such ultra-compact stars with the anisotropic matter, incorporating a suitable barotropic equation of state with Einstein's field equation to describe the matter distribution becomes challenging. Therefore, modelling and description of highly compact astrophysical objects has been of fundamental importance in astrophysics and has attracted much attention in the relativistic community.

This project aimed to find new models by solving Einstein field equations together with (or without) equations of states to describe a spherically symmetric, static compact anisotropic matter distribution that satisfies all major physical conditions of a real star.

Outputs

Two classes of new models were generated to describe static spherically symmetric compact objects with anisotropic matter distribution. The first model anisotropically generalizes the well-known isotropic models, which is achieved by transforming Einstein's field equation into a hypergeometric equation. The isotropic models of Durgapal-Bannerji, Tikekar and Vaidya-Tikekar are regained from our general class of solutions. Another class of model was generated by solving Einstein's field equations together with a generalized form of the equation of state, which allows us to extract models with various types of equations of states. The effects of various types of equations of states on the radial behaviour of physical quantities of a star have been graphically compared.

All these models generated smoothly match with Schwarzschild exterior metric at the boundary of the star and are shown to satisfy all major conditions of a realistic star: regularity of the metric potentials; a monotonic decrease of density, radial and tangential pressures with increasing radius; casuality condition. The stability is verified for all models using the adiabatic index and the concept of cracking. The equilibrium conditions are established through the generalized Tolman-Oppenheimer-Volkoff (TOV) equation. The above conditions are modelled to compare with some features of neutron star candidates reported in the literature.

Outcomes

The models generated were uniquely significant and two publications emanating in SCI journals with impact factors more than three, and well received by the global research community in the field. An MPhil student was introduced into this field and trained with financial assistance from this grant for the first two years; then it was upgraded to a Ph.D. and thesis submitted for evaluation with another publication in the SCI journal.

Way forward

The research has been further strengthened through collaborations with researchers from overseas (India and South Africa) as well as in the Department of Physics, Eastern University, Sri Lanka (EUSL); as a result, the General Relativity Research Group has been established and portrayed in the EUSL website. Further, studies have been initiated with the plans to train more PhD students.

Professor in Mathematics Department of Mathematics Faculty of Science Eastern University, Sri Lanka



Events & Staff Highlights

Meeting with Chinese Academy of Sciences to foster linkages on Water Sciences

A special virtual meeting took place on the 13th July 2023, between Research Center for Eco-Environmental Sciences – RCEES (a subsidiary of the Chinese Academy of Sciences – CAS) and the NRC, to foster linkages in research for Water and Environmental Sciences. It was the first meeting of NRC with the RCEES-CAS, on this topic and the meeting was mediated by Prof. Rohan Weerasooriya of the National Institute of Funda-

mental Studies (NIFS), who is also the principal investigator of one NRC Target Oriented (TO) grant project on water. Prof. Yuangsong Wei, Prof. Yawei Wang and Prof. Min Yang joined the meeting via zoom, representing the RCEES-CAS. Prof. Hemantha Dodampahala (Chairman), Dr. Shanika Jayasekera (CEO), staff officers of NRC Scientific Division participated the meeting representing the NRC.

A special discussion chaired by the Hon. Minister of Education



A special discussion to explore the possibilities of establishing a commercial drug production facility in Sri Lanka, took place on the 25th July 2023 at the NRC Board Room with the leadership of Hon. Minister of Education, Dr. Susil Premajayantha and patronage of Chairman-NRC, Prof. Hemantha Dodampahala. Aim of the discussion was to initiate a formal link between a commercial drug producer and a capable researcher from Sri Lankan academia, for the purpose of establishing a commercial drug production facility. Hon. Prof. Channa Jayasumana MP, Mr. Cyril Suduwella and Prof. Sameera Samarakoon (Institute of Biochemistry, Molecular Biology and Biotechnology - IBMBB) participated in the meeting representing the government and academia, while Prof. Chris Senanayake participated representing TCG Lifesciences (Pvt.) Ltd,, a leading global investor in the area of drug discovery, development and commercialization. Prof. Senanayake is the Founder & CEO of the TCG Lifesciences, who holds more than 150 patents in drug production. He is also the inventor of first HIV drug and HGL2 (used for diabetes medication). Dr. Shanika Jayasekera (CEO-NRC) and Mr. Sampath Nonis (Assistant Director of Scientific Affairs – NRC) also participated the event, representing the NRC.

Chairman NRC Prof. Hemantha Dodampahala participated as chief guest for the Annual Scientific Sessions of the Sri Lanka Veterinary Association - 2023

Theme: "One health for food safety and sustainable food production"



As a tribute for the services provided by the NRC to the Sri Lanka Veterinary Surgeons Association, the Chairman was invited for a guest lecture. The lecture highlighted steps to be taken to uplift the Sri Lanka Veterinary Surgeon's research profile and some important facts about occurrence of cancer.

Events coming up...

- Exhibition organized by the Ministry of Education in par with the National Science Week: NRC will be participating under the theme "Mysteries of human body to healthy life" – 8th to 10th November 2023.
- 2. The second Annual Research Symposium of the NRC 13th to 14th November 2023.
- 3. President's Awards for Scientific Research (Award Ceremony) for years 2019 and 2020 November 2023 (subject to confirmation by the President's Office).
- 4. Awarding of Public Private Partnership projects November 2023.

Appreciation of Service

Miss Sanduni Perera joined NRC on 01st October 2020 as a Management Assistant and she ended her service period on 25th September 2023. While appreci



ating her service, NRC wishes all the success for her future endeavours.

EDITORIAL COMMITTEE

Prof. H. Dodampahala / Chairman /NRC Prof. H. A. Dharmagunawardana / Council Member Prof. P. Ravirajan / Council Member Prof. T. Seresinhe / External Member Dr. Seetha I. Wickremasinghe / External Member Dr. Shanika Jayasekara/CEO /NRC COMPILED BY Nadeeka Dissanayake Scientific/Research Officer



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