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The Fourth State

Newsletter of the Institute For Plasma Research, Gandhinagar, Gujarat (India)

Manufacturing of the Prototype Large Volume Chambers of LIGO-India Project

Vacuum System is one among many systems which are integrated together in LIGO-India gravitational wave detector. IPR is responsible for procurement and integration of LIGO India Vacuum System. Vacuum System spanning four-kilometre length in two orthogonal arms, comprises of large volume chambers, adapters, spools, beam tube etc. Total 13 chambers namely Basic Symmetric Chamber (BSC – 05 numbers) and Horizontal Access Module (HAM – 08 numbers) are part of the detector. These chambers encapsulate key optical assemblies that shape the detector laser beam travelling back and forth across 4-km arms. Vacuum system provides ultra-high vacuum environment (≤ 10^{-9} mbar) for the operation of the detector. Combination of roughing pumps, turbo-molecular pumps, cryopumps and ion pumps are used to achieve ultra-high vacuum. Under Technology Development and Capacity Building (TDCB) phase of the project, IPR awarded the contract to M/s Vacuum Technique Pvt. Ltd. (VTPL), Bengaluru, to make 1:1 scale prototypes of BSC and HAM chamber.

Accomplishments of large size chamber prototyping activity:

Dual grade SS 304/304L plates in HRAP mill finish without any surface treatment is used in fabrication. CNC machines with 10-50 microns accuracies are used in machining parts and sub-assemblies. GTAW with high purity (99.999%) argon gas shielding / purging is used throughout fabrication. 100% ultrasonic testing of plates used & radiography of butt weld joints is performed to ensure quality. Geometrical tolerances on machined surfaces and other linear dimension range between 0.4 – 1.9 mm on distance ranging 300 – 1500 mm.

BSC and HAM chambers fabricated at VTPL, Bengaluru. Metrology performed using laser tracker, subsequently steam-cleaned.

Inspection, Assembly and Testing of Chambers:

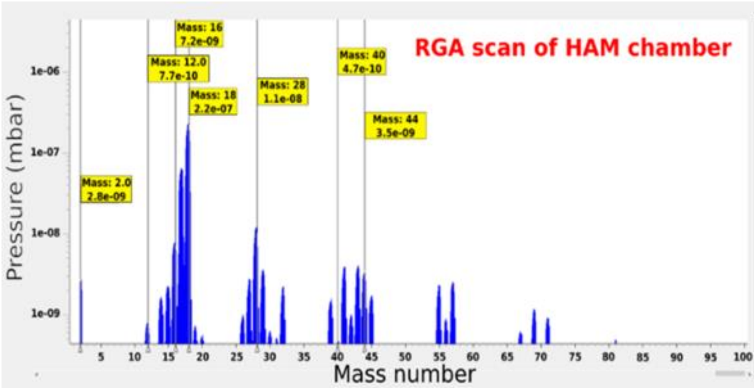
The chambers have combination of large and small flanges. Set of double O-rings on large flanges, while metal gasket on small flanges are used for vacuum sealing. Ultrasonic cleaning and vacuum baking @140^{0}C for 20 hrs of O-ring, while ultrasonic cleaning and natural drying of metal gaskets is done before their use in UHV. To ensure contamination free work environment, chamber assembly, leak testing and demonstration of vacuum were performed in classified cleanroom area.

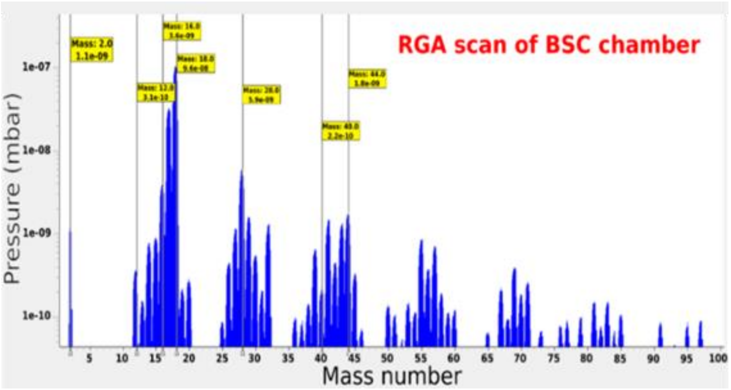
HAM & BSC chamber Assembly ready for He leak test, UHV compatible plastic hoods used for gross leak testing and subsequently for vacuum demonstration

Manufacturing of Prototype Large Volume Chambers of LIGO-India Project

Factory acceptance testing (FAT):

Laser tracker (accuracy 10-15 microns) is used in metrology to measure dimensions with close tolerances. Vacuum demonstration and Helium leak test for local and gross leak rate requirements fulfilled contractual specifications. The individual Helium leak rate in 10^{-10} mbar.l/s range while gross leak rate in the range of 10^{-9} mbar.l/s is achieved. Vacuum in both chambers – BSC (27 m^3) and HAM (11 m^3) - in the range of 10^{-8} mbar was accomplished in less than 100 hrs without baking using turbomolecular pumps of 3800 l/s and 1900 l/s respectively. The partial pressures recorded by RGA during intermediate stage of pump down shows BSC and HAM chamber without bake out is dominated by water vapour which is as per our expectations.





Residual partial pressure in (L) HAM and (R) BSC chambers during pump-down

Equipment	Unit	Basic Symmetric Chamber		Horizontal Access Module
Internal Diameter	m	2.6		2.1
Height	m	5.2		2.9
Wall Thickness	mm	12.7		12.7
Surface Area	m^2	52		27
Volume	m^3	27		11
Quantity	Numbers	1		1
Vacuum Requirement Main Volume Annulus volume	mbar	Acceptance	1.0×10^{-7}	1.0×10^{-7}
		Demonstrated	8.9×10^{-8}	8.2×10^{-8}
		Acceptance	1.0×10^{-5}	1.0×10^{-5}
		Demonstrated	4.0×10^{-6}	8.8×10^{-6}
Helium leak rate Local Global	mbar.l/s	Acceptance	1.0×10^{-9}	1.0×10^{-9}
		Demonstrated	5.2×10^{-10}	8.2×10^{-10}
		Acceptance	5.0×10^{-7}	5.0×10^{-7}
		Demonstrated	3.9×10^{-9}	4.6×10^{-9}

Functional Requirements of BSC and HAM Chambers

Acknowledgements:
LIGO-Division acknowledges contribution from members of working group (WG-1 & WG-2) and technical expert committee (TEC) in realizing this task. Without their support, the task would not have been accomplished in timely manner during COVID pandemic situation.

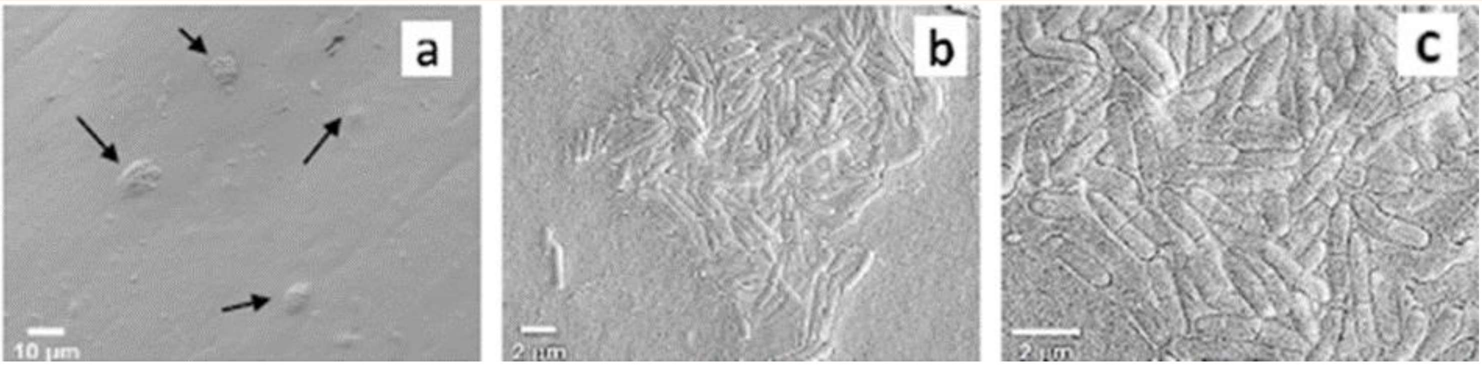
Rakesh Kumar, Vijay M Bedakihale, Dr. S. Sunil, Atul K Prajapati, Naresh C Gupta, Arnab Dasgupta, Hitesh K Gulati, Amit K Srivastava, Dr. Sabbir Ahmed, Prof. S Mukherjee

Antifouling Properties on Silicone Catheter Surface by Plasma Treatment

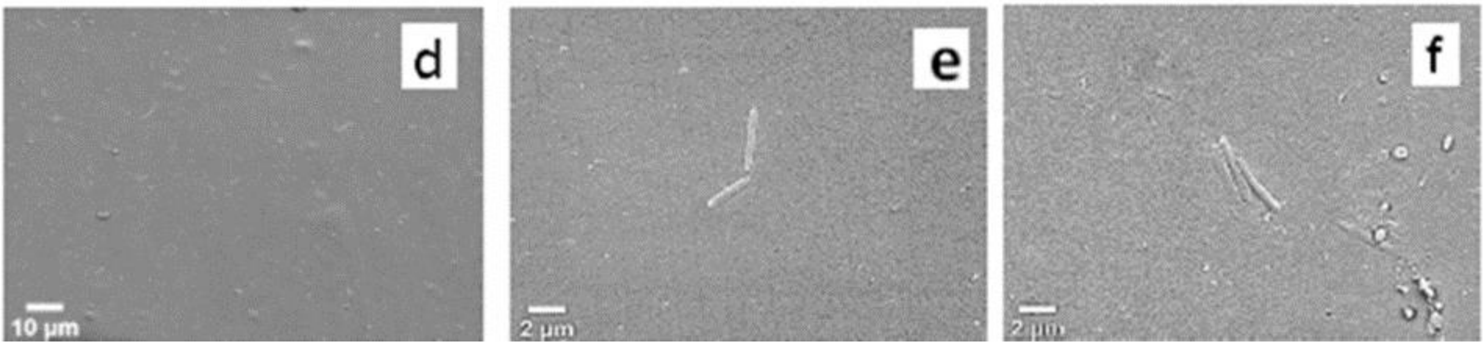
Catheter-related infections (CRIs) are one of the most common Hospital-Acquired Infections (HAI), caused by microbial colonization known as ‘biofilm’. This can lead to increasing morbidity and mortality of patients.

Researchers around the world are working on development of promising strategies based on material science and surface engineering to address these limitations. IPR’s study, based on an anti-fouling approach, involves modification in surface properties such that bacterial cells are not able to adhere and grow further.

Preliminary results reveal that a plasma-treated catheter surface has considerably altered surface chemistry and morphology. Microbiological test results have shown significantly less (~ 90%) bacterial adhesion on plasma treated silicone catheter surface as compared to the bare surface.



SEM (Scanning Electron Microscopy) images of bare silicone catheter surface at different magnifications, in which microbial colonies can be seen.



Images of plasma bare silicone catheter surface in which no such colonies are observed

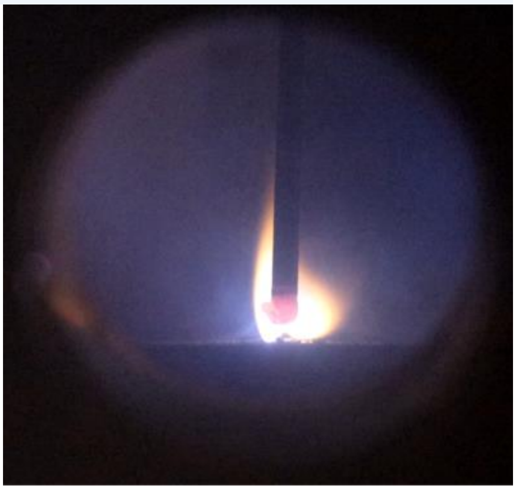
Effect of Cyclone Tauktae @ IPR

Cyclone Tauktae wrecked havoc in the eastern coastal areas of Gujarat and then swept past Ahmedabad/Gandihinagar on its way in land during the evening of 18th May, 2021, bringing with it, high winds and heavy rainfall. Many large and small trees in the IPR main campus were uprooted due to the high winds. No other serious damage was caused in the campus.

Atmospheric Plasma Division - Nanotechnology Applications

The Atmospheric Plasma Division (APD), functioning from the Facilitation Centre for Industrial Plasma Technologies campus also works on many exciting areas other than plasma pyrolysis, such as development of plasma systems for synthesis of nano-materials, systems for plasma processing of textiles, plasma systems for medical applications and so on.

Nano-science and nano-technology has generated tremendous interest among both researchers as well as technologists due to its potential applications in varied fields as diverse as biomedicine, optoelectronics and metallurgists. Thermal plasma route offers distinct advantages over conventional CVD or sol-gel techniques by doing away with drawbacks such as large time scales, multiple intermediate steps with impurities creeping in at various steps, low production rates or varied processes for varied materials. Thermal plasma is a high temperature process so ceramic nanoparticles can also be synthesized, other than the ability to yield high purity products and absence of vacuum equipment. Several nano-materials have been successfully synthesized in APD, such as zinc oxide (skin treatment, UV protection agent, whitening agent), iron oxide (contrast agent in MRI, therapeutic agent for hyperthermia based cancer treatments), nano-titania (photo-catalytic property used in self-cleaning fabrics, tiles, deodorising agent, UV protection agent, antibacterial agent), cobalt oxide (gas sensor, targeted drug delivery), graphene, SiC nanoparticles, nanowires and nanotubes (bio-medicine, gas sensing, hydrogen storage, field emission). An integrated, fully automated system has also been developed to produce as well as collect various nano-materials with low operational cost. An Indian patent has been filed and technology transfer done to three Indian Industries to produce zinc oxide nanoparticles at a commercial scale.



(L) Plasma-based nano-materials synthesis system at FCIPT campus (R) The plasma produced inside the system.

Obituary

Shri. Vipul K. Panchal
(10-Jun 1964- 20-May 2021)

Shri. Vipul K. Panchal joined PRL in 1986, in the Plasma Physics Programme and later moved to IPR with the Aditya Data Acquisition and Control group.

His major work involved Aditya operations. He played a major role in developing the Aditya Data Acquisition software in the early 1990s. An expert in FORTRAN-77 and C++ made him an invaluable asset to Aditya control and for running, upgradation and maintenance of the control software. He also was involved in operation, installation and maintenance of all computer hardware associated with Aditya.

His dedication to work was commendable in many ways. In the years that he single handedly managed the software part for 300+ data acquisition channels, there has not been even a single incidence of software failure.

He was a very gentle, humble and helpful man who spoke very little, however, it was his work that spoke for him. His colleagues remember him as someone who was always ready to help them troubleshoot issues with their diagnostics systems.

Shri Panchal left for his heavenly abode on 20th May, 2021.

IPR has lost a very dedicated and experienced staff and Shri. Panchal will always be missed. He is is survived by his wife Parul, son Jay and daughter Megha.

On behalf of all the staff members of IPR, ITER-India, FCIPT and CPP-IPR, I pray that his soul rests in eternal peace.

Chhaya Chavda

Obituaries

Professor A.K. Sundaram, former Dean and a past distinguished faculty member of IPR, passed away on April 30, 2021 at his residence in Indianapolis, U.S.A.

Prof Sen with Prof Sundaram in 1996

An internationally known plasma physicist he had played a major role in the establishment and early development of the Institute. One of the founding members of the Institute he belonged to the original team of seven scientists who had been handpicked by Dr. Vikram Sarabhai in 1971 to initiate a fusion program at the Physical Research Laboratory (PRL), Ahmedabad.

His active contributions in the research program planning and in the training of young `would be plasma scientists' at PRL were of considerable help in the formation of a core group for the fusion program that was launched in 1982. Subsequently as the first Dean of IPR he set up the administrative structure of the Institute and successfully oversaw its operation for a number of years. During those years his organized approach, attention to details and above all a very gentle and humane approach helped establish a very friendly and efficient environment – one of his truly lasting legacies to the Institute.

An accomplished theoretical physicist with a strong background in Applied Mathematics his research interests encompassed a wide range of topics spanning space plasma physics, fusion physics and fundamental aspects of fluid dynamics. Known for his detailed and rigorous calculations – all carried out in neat long hand- he tackled frontline problems related to magnetic reconnection in the magnetosphere, tearing and ballooning mode instabilities in tokamaks and fundamental aspects of basic fluid instabilities. His scientific accomplishments attracted international attention and led to invitations for collaborations and visits to a number of leading research centres in the world. After taking retirement from IPR in 1993, Dr. Sundaram immigrated to the USA and worked for several years at the Goddard Space Flight Center, Greenbelt, Maryland where he continued to actively research magnetospheric and ionospheric phenomena. However his heart always remained at IPR – as he was fond of saying – the organization that he had known from its infancy and had helped to grow and in which he had invested so much of his love and care. His demise is a sad loss for the IPR.

Dr. Sundaram is survived by his wife Jaya and daughters Vidya and Rekha.

Prof. Abhijit Sen

Dr. R. Srinivasan
(30-July 1968 - 06-May 2021)

Dr. Radhakrishnan Srinivasan made significant contributions in the field of tokamak research since his joining the Institute for Plasma Research (IPR) in 1991. His researches were focused on tokamak equilibrium & stability along with the design aspects of fusion reactors. He was very popular among young researchers and students and was regarded to be a great mentor and teacher!

He has successfully led the Magnet Technology Group for the development of superconducting magnets and the operation & maintenance of toroidal and poloidal magnet coils of SST-1 tokamak. He was also instrumental for conceptualizing and implementing the High Performance Computation Facilities in the Institute and was actively involved in the computer modelling & simulation activities. He has also made significant contributions in the ITER project activities as dedicated members of various advisory committees.

The youngest member of a middle class family from a small village of Tamilnadu, he had dreamed to be a researcher in Physics. He gave up his first job (after M.Sc.) at the Cotton Research Institute at Nanded (Maharashtra) and opted for the Ph.D. program in Plasma Physics at IPR.

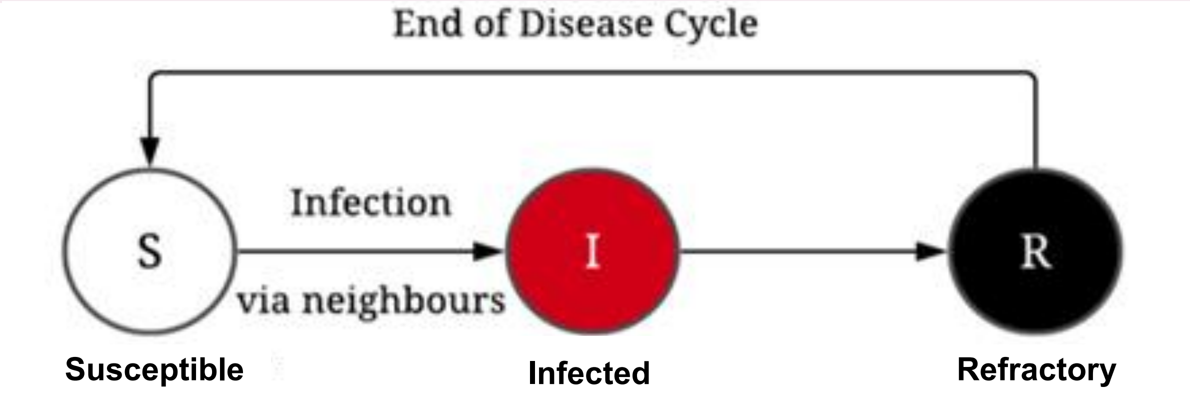
Dr. Srinivasan left for his heavenly abode on 6th May, 2021. He is survived by his wife Ranjani and son Radhakrisnan

There are so many fond memories with him, a soft-spoken, ever smiling and a very gentle person and a philosopher too. His passing away has left a big void in the Institute. We all will miss him. On behalf of all the staff members of IPR, ITER-India, FCIPT and CPP-IPR, I pray that his soul rests in eternal peace.

Dr. Daniel Raju

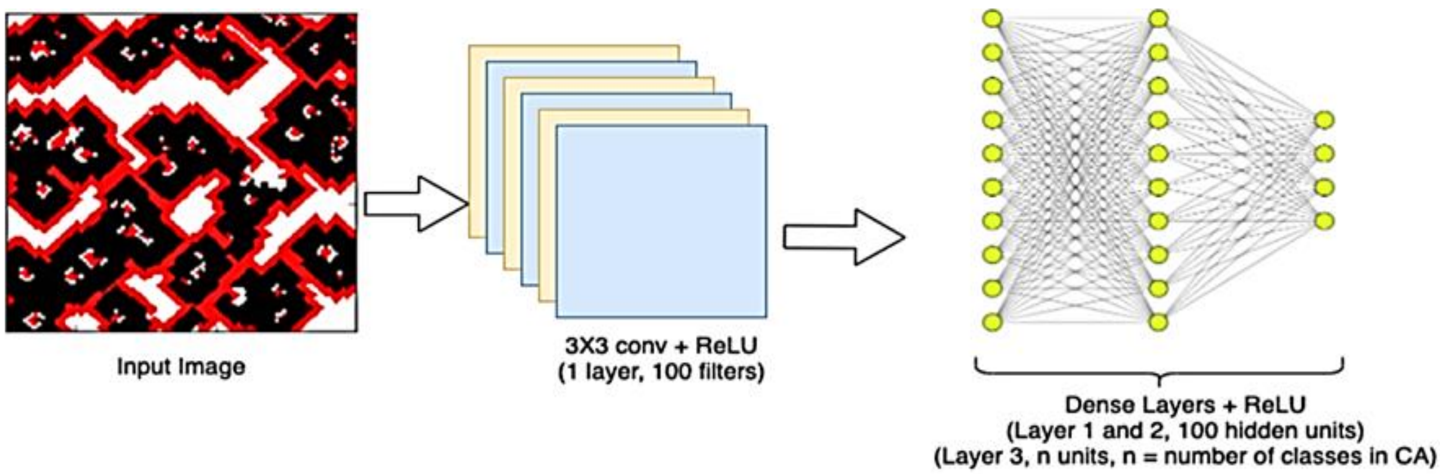
HPC Corner : Prediction of Cellular Automata (CA) Using Neural Networks

Cellular automata are models of complex systems as a collection of simple coupled dynamical units, arranged in discrete space, evolving in discrete time, from one discrete state to another. They are a computationally light and simple platform to model complex, collective emergent phenomena, which is usually difficult to predict precisely. Cellular Automata are very effective in mimicking the spread of disease based on different models. In the work [1], SIRS (Susceptible, Infected, Refractory) model of disease spread is implemented, to explore the emergence of persistent infection in a closed region. **A specific CA system, known as the Greenberg-Hastings CA, which was originally proposed in the context of excitable dynamics, has been found applicable in the context of studying the epidemic spread of diseases in a population, analogous to the scenario of the Covid-19 pandemic.**

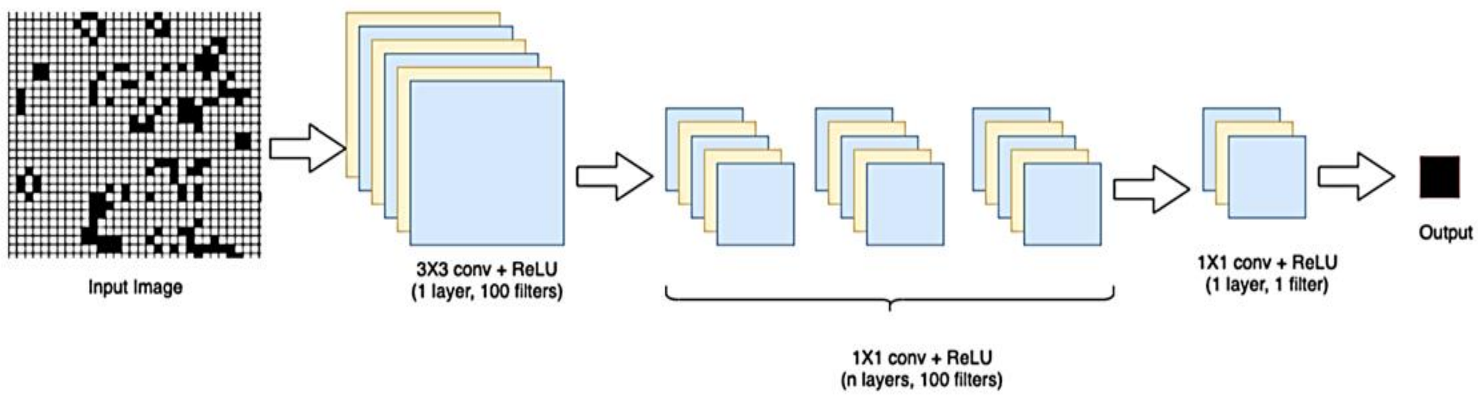


Schematic representation of SIRS Cycle

In the last few decades, advances in the understanding of neural networks has enabled their application for prediction in myriad avenues. In a recent joint project between researchers of IPR and NIT K, the ability of a convolutional neural network to predict the asymptotic fate of a cellular automaton, was studied. We propose two architectures shown in figure 2 and 3. Both networks performed almost similar with similar metrics for game of life and covid dataset, but for SIRS dataset, network with 11 layers of 1 x 1 convolution seemed to perform better than the dense network. It was found that certain neural network architectures were more successful at predicting the successive configurations of the cellular automata. This study opens doors to develop an understanding of the mechanism by which the rules of the cellular automata are being imprinted onto the neural network, thus improving the explainability of the predictive ability of neural networks in a dynamical context.



Proposed CNN architecture using dense layers to learn ruleset of any arbitrary CA.



Proposed CNN architecture to learn ruleset of any arbitrary CA (Using Multiple Convolutional Layers with 1 x 1 Filters)

Past Events @ IPR

- **Mr. Soumen De Karmakar,** gave a talk on "*Effective thermodynamic properties of inertial active microswimmers with alignment interaction*" at APS March Meeting, American Physical Society, 15-19 March 2021
- **Mr. Naveen Rastogi**, gave an invited talk on "*Remote Handling and Robotics Application in Tokamaks" for the Faculty Development Programme (FDP) on Artificial Intelligence, Robotics and Automation"*, organized by Banasthali Vidyapeeth, Rajasthan, during 20-25 March 2021
- **Dr. Rohit Mathur**, IIT, Dhanbad, gave a talk on "*Design and Implementation of Printed Ultra-Wide Band MIMO Antenna for Wireless Communication Application*" on 26 March 2021
- **Dr. Pravin Dwivedi**, IIT Delhi, gave a talk on "*Development of Nanostructured Metal Oxides-Carbon Composites for Re-chargeable Ion Battery*" on 31 March 2021
- **Dr. Bivash Dolai**, Guru Ghasidas Vishwavidyalaya, Bilaspur, gave a talk on "*The rotating Rayleigh-Taylor instability in a strongly coupled dusty plasma*" on 9 April 2021
- **Dr. Vishant Gahlaut**, Banasthali Vidyapith University, Rajasthan, gave a talk on "Thermo-*Mechanical Analysis and Simu-lation of Helix TWTs*" on 16 April 2021
- **Dr. Sagar Sekhar Mahalik**, gave a talk on "*On the resonance absorption in laser-driven deuterium cluster*" on 19 April 2021
- **Dr. Sandip Dalui,** Jadavpur University, Kolkata, gave a talk on "*Some Problems on Nonlinear Ion Acoustic Waves in Two Electron Temperature Plasma*" on 23 April 2021
- **Dr. Suryakant Gupta**, gave an invited talk on "*Pulsed Power technology and its Pervasive use for Societal Applications*" for the Post Graduate students of Electrical Engineering Department of Nirma University, on 11 May 2021
- **Dr. Sonu Yadav**, gave a talk on "*Development of high power Helicon Plasma Thruster (HPT) and up-gradation of Helicon eXperimental (HeX) device*" on 11 May 2021
- **Mr. Rakesh L. Tanna** from AOD delivered an Overview Presentation entitled "*Overview of Recent Experimental Results from the ADITYA – U Tokamak*" in 28th IAEA Fusion Energy Conference (FEC-2020), which was held virtually during 10th to 15th May, 2021

Upcoming Events

- Plasma Surfaces and Thin Films, Institute of Physics, United Kingdom, online, 9 June 2021 : https://events.iop.org/plasma-surfaces-and-thin-films-1
- 47th Annual European Physical Society (EPS) Conference on Plasma Physics, (online), Spain, 21-25 June 2021 : https://epsplasma2020.eu/
- 20th International Congress on Plasma Physics (ICPP 2021), South Korea, 27 June 2021-02 July 2021 : https://icpp2020.kr/

Effect of Cyclone Tauktae @ IPR

Know Your Colleagues

Mr. Manishkumar M Vasani joined IPR as Engineer-SC (Instrumentation & Control) in October 2007 and is presently working as a Scientific Officer – E in the WC & AC Section. He contributed in the upgradation of SST-1 water cooling SCADA system and maintenance and installation of field instruments in WCS & WDS systems. He participated in projects like VRV AC system of additional offices building, N-NBI WDS field instrumentation, LHCD WDS field instrumentation, revamping of NBI WDS system with field instruments. Presently, he is working as a Section Head – WC & AC and some of the major projects executed under his supervision are HVAC systems of new R&D Lab building, DX AC system of Neutronics Lab building, Canteen AC system renovation. Operation and Maintenance of HVAC and Water Cooling Systems of IPR and FCIPT are also a part of his job.

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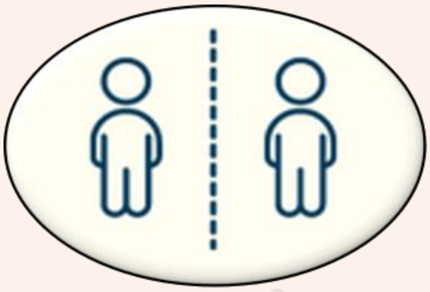
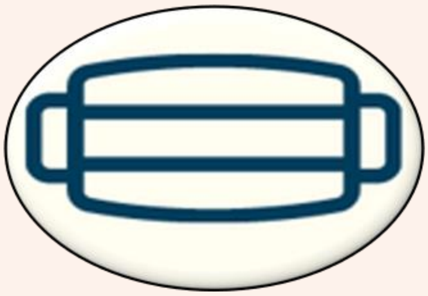
Help Fight The Covid-19 Pandemic

Wash Your Hands frequently With Soap



Ensure Social Distancing At ALL times



Always WEAR a Mask When you go outside

- Avoid touching your eyes, nose and mouth
- If you have fever, cough and difficulty in breathing, seek medical care early
- Stay informed and follow advice given by your healthcare provider
- Inform Office immediately if you or any family member tests positive
- Follow SMS - Social Distancing : Mask : Soap/ Sanitizer
- Strictly follow social distancing while outdoors, especially at work.

Please get yourselves vaccinated against Covid-19

कृपया अपने आप को कोविड -19 के खिलाफ टीकाकरण करवाएं

For your safety and for the safety of your co-workers, ensure that you always use Arogya Setu App

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