UNIVERSITY OF SURREY

SPATIAL STRUCTURES RESEARCH CENTRE

ISSN 2634-8551

SPATIAL STRUCTURES MOVERS AND SHAKERS

Volume 1, Issue 1
September 2020

UNIVERSITY OF SURREY

SPATIAL STRUCTURES RESEARCH CENTRE

CONTENTS

UNIVERSITY OF SURREY

SPATIAL STRUCTURES RESEARCH CENTRE

INTRODUCTION

The *Spatial Structures; Movers and Shakers* e-magazine is part of a series of activities in preparation for the [Spatial Structures 2020/21 conference](), which will be held at the University of Surrey.

In the spirit of the key theme of 'Inspiring the next generation,' this e-magazine aims to reach out and encourage young people to enter the field of spatial structures, as well as to motivate everyone involved in this field.

To do this, we celebrate the life, work and achievements of world-leading individuals and organisations in the field of spatial structures. We commend their outstanding contributions to research and education, as well as those in design, fabrication and construction. Each article chronicles one person's story, and is also based on a written or virtual interview – available through the YouTube channel, '**SpatialStructures2021**' – that consists of a series of Q&As and a section entitled 'Your space, your structure', where they present some of their projects and inspirations.

This e-magazine is published by the Spatial Structures Research Centre at the University of Surrey. We hope you enjoy this new publication.

UNIVERSITY OF SURREY

SPATIAL STRUCTURES RESEARCH CENTRE

INTRODUCTION TO ISSUE ONE

DEAR READERS

We're happy to present to you our new e-magazine, *Spatial Structures; Movers and Shakers*. This is our first issue and we prepared an interesting selection of people and organisations, which we hope you can enjoy from the comfort of your home.

About a year ago, many of us were in Barcelona, Spain, celebrating the 60th anniversary of the IASS. We enjoyed a rich variety of sessions, lectures, workshops and an amazing exhibition of pavilions, organised by the Working Group on Advanced Manufacturing and Materials of the International Association for Shell and Spatial Structures (IASS WG21). Of course, there was a lovely city and glorious weather, too. What we didn't know was that, a year later, it wouldn't be possible to reunite again to celebrate the IASS annual symposium and Spatial Structures conference 2020 at the University of Surrey, UK, as originally intended.

Covid-19 turned our world and our lives upside-down. This pandemic reminded us that we don't only need to design and construct resilient spatial structures, but that we also need to be resilient and adapt to change ourselves. There is no doubt that Covid-19 has had devastating outcomes for many and we still need to work together to get through it. But, as with every challenge or tragedy, this pandemic offers new ground to grow new ideas, to innovate and to be creative to help solve current problems – something well put by one contributor featured in this issue.

As you may know, the decision was taken to postpone the conference to August 2021, but we wanted to make the most of this year. And so, even though we can't meet to celebrate the joint event, we want to do justice to the key conference theme of 'Inspiring the next generation'.

As mentioned in the introduction, this e-magazine is intended to motivate young people to be part of the next generation of leaders in the field of spatial structures. And we're planning to do that by presenting to you in every issue individuals and organisations dedicated to this field in different ways, such as research, teaching, design, fabrication, construction, etc.

The world requires more people engaged in this field to help build better houses, structures, artefacts, buildings and cities to fight climate change and achieve a more sustainable future.

This issue presents the life and career of four leaders in the field: Dr Sigrid Adriaenssens from Princeton University, USA; Dr Haresh Lalvani from Pratt Institute, USA; Dr Carlos Lazaro from Polytechnic University of Valencia (UPV); and Dr Juan Gerardo Oliva Salinas from the National Autonomous University of Mexico (UNAM). We also examine the work of Novum Structures UK Ltd, an outstanding industrial organisation; and Mola, an innovative idea for education.

We can't wait to see you all at the University of Surrey in August 2021. In the meantime, we hope you find this new e-magazine inspiring. We wish you and your loved ones good health.

Yours sincerely,

S Alireza Behnejad, Editor
Martha Godina, Assistant Editor

September 2020

We are grateful for several colleagues who have been helping us in preparation of this issue, in particular, Alicia Barnes, Charlie Engel and Peter La.

HARESH LALVANI

Dr Haresh Lalvani is a tenured Professor and Director of the Center for Experimental Structures at the School of Architecture at the Pratt Institute, USA, and the principal of Lalvani Studio in New York. He has been an honorary member of the *International Symmetry Association* (ISA) since 2016 and part of the editorial board of the *International Journal of Space Structures* since 1985.

Haresh is an internationally recognised architect-morphologist, artist-inventor and design scientist. He has collaborated across many disciplines – from computer science, physics and engineering to dance. He obtained his bachelor's degree in architecture at the Indian Institute of Technology in Kharagpur, India, in 1967; his master of science in architecture at the Pratt Institute in 1972; and his PhD in architecture from the University of Pennsylvania in 1981. He worked in collaboration with Milgo/Bufkin, New York, as an independent inventor, sculptor and designer (1997-2014). He has worked at NASA Langley Research Center on space applications (1989-1990); at the pioneering Computer Graphics Laboratory, NYIT, on computer animations in the 1980s; and at the Tata Institute for Fundamental Research in Mumbai in 1977 and 1982 on early polyhedral transformations and computer-generated geometric patterns.

Haresh has developed many designs and inventions, and has patented many of his inventions. In 2002, he received the Pioneers Award from the Spatial Structures Research Centre at the University of Surrey for his distinguished contribution to the field. In 2016, he was awarded the Cosmic Fishing Award presented by the Synergetics Collaborative (SNEC) at the Rhode Island School of Design (RISD); in 2018, the Distinguished Alumnus Award from the Indian Institute of Technology; and in 2020, the Pratt Institute's Research Recognition Award.

RESEARCH CONTRIBUTION

Haresh has spent the last 50 years investigating in different areas of architecture that deal with fabrication, mathematics, morphology, genetic codes, biology, biomimicry, organic architecture and growing architecture among others, with the continuing aim of mapping the morphological genome [1]. In 2018, he published a compilation of last four decades' work in an article entitled 'Morphological Universe: Genetics and Epigenetics in Form-making' in a special issue of *Symmetry: Culture and Science* [2]. More recently, in 2020, he published an article entitled '4D-cubic lattice of chemical elements' in *Foundations of Chemistry* [3], to commemorate the 150 years of Mendeleev's original publication. He has self-published two books, '***Transpolyhedra: Dual Transformations by Explosion - Implosion***' in 1977, and '*Structures on Hyper Structures*' in 1982. He is currently working on a new book, '*Coding, Shaping, Making: Experiments in Form and Form-making*'.

CONTRIBUTIONS TO EDUCATION

Haresh introduced Morphology at Pratt Institute in 1972, a concept which has evolved over the years from a single course to a programme which has proved highly successful. Since 2014, Morphology has been offered as a Concentration for undergraduate architecture students and a Minor for students from other departments (interior, industrial and digital design and sculpture among others). There are currently four **Morphology studios** being taught by his colleagues, CheWei Wang, Ajmal Aqtash, John Gulliford and David Burke. The assignments are different for every studio, but all experiments are open-ended to encourage the spirit of discovery and invention using analogue and digital means. The experiments include architectural studies of complex compound-curved surfaces and their physical realisation using various construction systems such as membranes, grids, tensegrity, origami, crochet, shells and masonry techniques, combined with digital fabrication, 3D printing, robotics and actuation technologies.

CONTRIBUTIONS TO EDUCATION CONT.

The Morphology programme is the academic component of the **Center for Experimental Structures'** activities. There is also a research component which permits undergraduate students to get involved in faculty research.

DESIGN AND FABRICATION

Haresh is the inventor of the AlgoRhythms and Xurf product lines which he developed in collaboration with Milgo-Bufkin, a leading architectural metal fabricator in New York. Haresh met Bruce Gitlin, the owner of Milgo-Bufkin, in 1996 through his colleague John Lobell. Their collaboration lasted over 17 years, during which time they developed five group of projects, which he calls the 'Milgo Experiments', and which identified six basic principles for the fabrication of sheet metal-like material, including folding metal surfaces among others. The principles include seamlessness, self-shaping, variable forming (to achieve variable properties such as rheology, density, strength and opacity), mass-customisation, conservation of cost, and conservation of mass.

For their first project, AlgoRhythms (1997-2004) [4,5], they developed a method of fabrication to generate infinite folded forms in one material using a morphological algorithm. This method was considered among the pioneering examples of industrial mass-customization in architecture [6] (see Fig. 1). Haresh's AlgoRhythms Columns are in the permanent design collection at the Museum of Modern Art (MoMA) (see Fig. 2).

For the second project, Xurf (1998-2010), they developed a method to produce asymmetric compound-curved surfaces from flat metal sheets by applying force in various ways, morphing 2D sheets into 3D states at room temperature.

In their third project, X-Structures (2008-2014), they experimented with the rapid-forming and self-shaping of metal flat sheets to produce 3D forms by applying force in one direction to expand the sheets. In the project Hypersurfaces (2006-2012), they bent metal sheets to create 2D surfaces with positive curvature (e.g. the sphere) with the aim of further developing surfaces with negative curvature (e.g. saddle surfaces). Finally, in Morphing Platter (2010-2011), they developed a parametric design method to allow for conservation of cost and mass while enabling mass-customization. In this **short video**, Murray Moss talks about the exhibition entitled 'Haresh Lalvani: Mass Customisation of Emergent Designs' at Design Miami 2011.

Fig. 1 ALGORHYTHMS product lines - panels and columns, 1999 (image credit Milgo Bufkin) [4,6]

Fig. 2 ALGORHYTHM COLUMNS in folded titanium, Museum of Modern Art (MoMA), New York, 2004

INTERVIEW

We had the opportunity to conduct a written interview with Haresh in August 2020. Similar to our virtual interviews, this interview consists of a series of Q&As and a section called 'Your space, your structure'. In this section we bring you a brief account of the interview, including what he had to say about his experiences during lockdown, his love for art and mathematics which led him to architecture, his visit to the University of Surrey, and his experiences working with Milgo-Bufkin. This is followed by the 'Your space, your structure' section and finally, a few answers which we thought deserved to be told in his own words.

Haresh has seen the lockdown as an opportunity to evaluate our relationship with nature. He says that our challenge is to partner with nature, and that Covid-19 has given us the time to think about the role we play in addressing challenges in relation to the future of our planet. He refers to George Church, who said that among the positive results of the pandemic are the incredible scientific collaborations across nations to find a vaccine, and highlights the fact that we need to work together to solve common problems such as Covid-19, climate change, the depletion of natural resources, loss of natural habitats, increased hurricanes and floods and other environmental issues. On another level he says that he has been surprised by the intense online interaction with students the pandemic has brought, which has allowed him more in-depth exchanges.

It was Haresh's affinity for art and mathematics that led him to architecture. He says: 'Architecture is perhaps the most porous of disciplines as it permits ideas from any discipline to enter its thinking.' He was honoured when, in 2002, he received the Pioneers' Award at the fifth international conference on Spatial Structures given by the University of Surrey's Spatial Structures Research Centre. Haresh recalls that Lancelot Law Whyte (in the spirit of D'Arcy Thompson) predicted that there would be a Department of Form in academia by the end of the last century in his *Aspects of Form* in 1968. Whereas this did not happen, for him, it was a very important moment since the University of Surrey was the first to recognise fundamental studies in form with this award.

Haresh attended three conferences at the University of Surrey from 1984 to 2002. He recalls these conferences with much enthusiasm, remembering: 'The large green rolling field, the singular tetrahelix, more full-scale joints in real materials than I had ever seen before, more people in discrete structures than I had known, the charmingly fat and heavy conference proceedings, and some of the nicest people you could meet.'

During these conferences, Haresh met many distinguished colleagues and pioneers working in the field. He felt that although morphology was not the focus of the conference, the audience was very receptive to ideas in this area, and successive conferences became ever more inclusive. In particular, he recalls meeting Professor Nooshin, with whom he shared some special memories. 'A special relationship with Nooshin developed,' he says. 'I was so enamored that someone could invent a new algebra and asked if he could teach me. He responded enthusiastically and we drove from his office to his home for a sit down with its laptop. Within a short period of time we realised I was unteachable and we stopped. This was unintended and not anticipated. I realised I had squandered a once-in-a-lifetime opportunity to learn from the master. I hope I was forgiven for being a poor student.'

During this time, Haresh published several papers in the conference proceedings as well as in the *International Journal of Space Structures*, which originated at the University of Surrey. He edited a special double issue of the journal Morphology and Architecture and wrote a chapter on 'Morphological Aspects...' for *Studies in Space Structures*, a book written by Nooshin and dedicated to Z S Makowski. These publications marked an important plateau in Haresh's ongoing work.

In the spirit of the theme of the next Spatial Structures conference 2020/21, 'Inspiring the next generation', Haresh finds young people's involvement in climate activism very inspiring, and says that it is the next generation who are publicly challenging the political will for new and rapid legislations. He hopes that some of this passion can be focused on finding architectural, design and technological solutions for the issues our planet is facing.

Haresh presents three projects in the 'Your space, your structure' section of the interview. In 2012 he built the public sculpture SEED54 (see Fig. 3) in midtown Manhattan, part of the Hypersurfaces series developed in collaboration with Milgo using a stainless-steel cut pattern. This sculpture represents Haresh's interests in seeds as essential carriers of information for the propagation of life. He tells us that this new morphology was created based on a sphere from non-convex hexagons since a sphere from convex hexagons is not possible – see the article '**A play on Nature's Patterns**' by the New York Times. He explains: 'SEED54 has a new geometry. We don't know yet if it exists in nature. Maybe someday it will, with or without our help.'

In 2015, Haresh designed the NYCxDesign Pavilion for the New York Design Week (see Fig. 4). Although the design was not built for budgetary reasons, this was an opportunity to design a 3D Hypersurface for a functional space. This was an example of a 3D space projected from five dimensions – an idea that is currently being applied to a sculpture with the shape of a 3D version of the Mobius strip.

The last project highlighted, X-POD138, was built in 2014. This is a prototype (see Fig. 5) of the X-Structures series, fabricated using self-shaping methods to build an emergency shelter. It was displayed at OMI Arts International Center, Ghent, NY. There was no 3D digital model of the structure: the flat sheets were formed under force and the eye-shaped opening and the 'eyelid' beams emerged during the forming process.

Fig. 3 SEED54 in Manhattan, 2012 (photo credit Peter Tannenbaum)

Fig. 4 NYCxDESIGN Pavilion for the New York Design Week, 2015

Fig. 5 X-POD138 in OMI Arts International Center, Ghent, NY, 2014

INTERVIEW CONT.

When did your interest in spatial structures develop? Is there a role model or a particular structure that inspired you?

During the last year of my undergraduate studies in architecture in India (1967), I was fortunate to be allowed (a gift) to pursue an independent search for my thesis project which asked two questions. The first is the same I am asking today though it was less developed at the time, and I was able to answer the first part of the second question in 1973.

Regarding the first, I wondered about similarities between architecture and nature, settling on form as the starting point. This made me look into other fields (mathematics, biology, chemistry and engineering). Fortunately, this was at IIT (KGP) and there were other departments outside architecture which made it easier to find supportive STEM faculty who found time to engage. During that period, I was privileged to receive the generous support of architecture faculty, notably, Professors M A Rege, H D Chhaya, and G Mitra. The interactions with Dr Sahib Ram Mandan (Mathematics) who loaned me his exquisite wooden models of polyhedra and would give me feedback on my drawings, Dr B Chatterji (Chemistry) on shapes of molecules, Prof A P Gupta (Civil Engineering) on structural principles and physical tests of natural fibers and an egg shell, and Dr De (Agriculture) on plant morphologies were inspiring and broadened the scope of the work. The idea of connecting different forms and structures in different fields made me wonder at the time if there was a 'universe' or 'multiverse' of form. I use the terms form and structure interchangeably since all structures are spatial forms and all forms are spatial structures (topologically speaking).

The second question made me wonder at that time why we didn't use bone and spider silk for building. This was resolved, in part, with David Baltimore's discovery of reverse transcriptase in the early 1970s. All amino-acid sequences of (structural) proteins could now be reverse-transcribed to their DNA sequences and, with new developments in protein-folding, can be used with genetically engineered bacteria to produce natural building materials. I presented the first part of this idea at UPenn in 1973 when Anne Tyng invited me.

Both questions led me to reach out to many individuals and their responses fueled me. Bucky Fuller was kind enough to respond, wishing me luck and thanking me for interest in his work – I had read his available works and re-built some of his models. Robert Le Ricolais responded several times speaking of 'automorphism'

INTERVIEW CONT.

and shared his advice: 'If I were to start over, I would start with geometry as my point of departure'. Frei Otto's work led me to his biologist collaborator, J G Helmcke, who was very enthusiastic and sent me stunning stereo micrographs of diatoms. These were breathtaking and are still some of the most beautiful creations of nature. Helmcke's images left a deep impression on me, and I still wonder how diatoms build their fluid forms from a hard material like glass at the micro scale. Otto and Helmcke jointly started the 'Biology and Building' program in 1962 and the work, spanning several decades, was recorded in the landmark IL series which I discovered after I joined Pratt in 1970. Peter Witt shared his work on spider webs and Robert Horne on viruses, and there were others.

During that period, I also collected random examples of shells, crystals, seeds, bones, leaves, and so on. Today, I am returning to the first three, crystals, seeds and seashells, with a broader view I had at the time. At Pratt, I also met Bill Katavolos who shared his pioneering and inspirational work with me in 1975 and taught me De Morgan's law with his colored cubes and 3D matrices, an idea that has provided a stable reference for my work since. Then, there was the memorable visit to see Gaudi's work in person, and also a side trip to Al Hambra, in 1978.

Could you share with us your experience of studying under the supervision of Buckminster Fuller?

I have avoided going there since this gets into personal matters. In my final year as an undergraduate student, besides re-constructing many of Fuller's models in the 'Dymaxion World….', I was enamored by his scale-free approach from nano-scale to planetary design. More important was his way of seeing nature as a problem-solver. This was profoundly impactful. He was the first to connect nano-technology with design and, in the late 50s, his was the first example of an influence from design to science. His 270-strut tensegrity structure from 'identical' units inspired the Caspar-Klug quasi-equivalence theory of viruses for the arrangement of more than 60 permissible identical protein subunits on the sphere. By the time I met Fuller in 1976 to begin doctoral work (another gift), I had met the scientists who had worked on viruses and other macro-molecular biological structures. So from the day he had responded to my first letter about 10 years earlier, to the second, a 3-page stream describing why I wanted to see him, he already had a larger-than-life presence in my formative years. On one hand it was humbling to be in his presence, on the other it was beyond inspiring to see him immediately recognise his presence in my work at the time and lend it full support.

The supervision you speak of was unconventional. It was a rare privilege to be afforded the freedom to pursue one's own search. With freedom comes responsibility, and the fact that he entrusted me with this responsibility has continued to give me strength to move on. Today, I still feel his silent presence. Two examples come to mind: his question to me, and a comment. During my doctoral review, he asked: What does the colour red mean to you? This was a comment on the coloured models, the result of colour-coding space and its inhabitant structures. I still don't have the answer. But to Bucky, our sensorial modes were important and made him wonder about the smell of a tetrahedron. He was linking synesthesia with geometry. Second is a startling statement he made during a train trip from New York to Philadelphia (our formal meeting around Spring 1978 since his scheduling wouldn't permit another time): the atom will become the computer. I still think about it.

Looking back, what I find interesting is that during our infrequent meetings, all show-and-tell at the end of each semester to share work (and also satisfy academic requirements like grading), not much was said but a lot was exchanged. This I found remarkable. He had made *Synergetics* required reading for me and had gifted me a signed copy, I understood that synergetics geometry was a physical one with no place for zero, infinity, or an infinity of digits after the decimal place in *pi* (hence having no physical meaning). So when I showed him the higher-dimensional diagrams, though I was careful not to use the term hypercube in describing them, he seemed to have accepted them as organising systems even though they contained the abhorrent cube.

Looking back, it was a rare privilege to have known him, a bit. I also realised that meeting him was inevitable. The first meeting was formal when he accepted the request to be my doctoral advisor, but the second was memorable after he saw the new work. His remark, 'Nature had brought us together', captured the experience.

How did your long-term research on 'architectural genome' develop in terms of ideas and inspiration?

If nature is to inform our designs, we need to understand it. But here's the challenge: how are we to access nature's design principles without the skill sets and knowledge to understand it at a granular level? This obligated me to seek out scientists and their works in structural biology in the early to mid-70s. I met with practically all of them during that period through the virologist Tom Benjamin at Harvard Medical School. James Watson was kind enough to invite me to the Cold Spring Harbor Laboratory to attend one of the bacteriophage meetings and some of my studies on folding of pentagonal tessellations were published on the cover of their abstracts (1976). That cover image dealt with kirigami, part of an important early work that is still unpublished, and marks the period I got interested in self-assembly, in part wondering how the viruses pulled it off. Self-assembly in outer space came to mind. The meeting and conversations with scientists at CSHL and elsewhere made me think of genetics of architecture and its DNA. There wasn't any, and that set an agenda in motion with form providing a starting point.

INTERVIEW CONT.

As I started connecting individual forms and structures to others in diagrams, I began to represent them with a code, numeric or alphanumeric, occasionally graphic. My doctoral dissertation (1981) [7] introduced higher-dimensional diagrams as maps of structures with their codes as spatial addresses and a continuum between 0 and 1. This was the beginning of the morph-code I have been working on since. The similarity to DNA, a linear code, was mentioned in an exhibition catalog (1982) relating to Islamic patterns, the ones found in the tiles and grills of the famous Moghul buildings in India, one of them being very close to the high school I went to. This project automated the generation of related patterns by punching linear sequences of numbers (alpha-numeric codes) ad infinitum, as in the linear DNA sequences. This theme has continued in my work since and expanded into mapping the Morphoverse, a morphological universe that is an open-ended, expansive, interconnected and nested higher-dimensional periodic table(s) of form.

This early interest in connecting (seemingly) unrelated forms has been perfected in another field, biology. It is biology's grand unification. Darwin's great insight that two finches come from one was the discovery that each species, a point in space, branches forward in evolution to two points in space as a way for evolution to proceed. More importantly, in reverse (and applied recursively) it takes us back to the origin. So when you speak of a 'spatial structure', here is a neat example of one, though it is a meta-structure and not a physical one. This self-similarity between a physical structure and its underlying conceptual structure has been one of my proudest discoveries. There isn't one particular structure of interest, but the relationships between them within a higher-dimensional framework wherein one structure morphs to the other in a continuum. The 'tree of life' and the discovery of the structure of DNA, two of the greatest discoveries in biology, are the two lasting models that continue to inspire my thinking.

Your research covers a wide range of areas such as morphology, mathematics, genetic codes, biology and biomimicry, organic architecture, growing architecture and fabrication among others. With insight from all these areas, what would you say is your vision for the future of architecture and fabrication? And do you think we will see some of these futuristic visions in the upcoming Spatial Structures 2021?

In nature, form, process and material are one. In architecture, we have been heading in this direction in recent years, as is evident from the very exciting works by many individuals and groups that are combining design with computation, robotics, manufacturing methods (additive and subtractive), morphing and architected materials, various biotechnologies, genetic engineering, self-assembly, and related developments. I will not address these though there are overlaps and parallel interests. Instead, I will speak from my limited experience with industrial fabrication from the Milgo Experiments mentioned earlier, combined with my long-term work in mapping the Morphoverse, also mentioned earlier and dealing with generation of form, its inter-connectivity, coding and continuous transformations within an extended periodic table.

I mentioned the continuing work on the periodic table of form. A similar approach will be needed for a periodic table of processes and materials which can then be combined with form. A unification of the form-process-material triad will be an important resource for design and production possibilities. Imagine the way an artist creates new colours from three primary colours, or a chemist or material scientist creates a new material from the same periodic table of elements – shouldn't an equivalent source be available for architects, designers, engineers, fabricators and makers to combine form with their chosen processes and chosen materials? A seamless form-process-material triad may provide an insight into how nature builds its incredible designs, and also enable us to create our own in a greater harmony with it. A built-in economy in such a seamless system would be expected.

The role of transformational geometries and topologies, both physical and conceptual, in achieving this unification will be increasingly recognised and will continue to impact fabrication methods and new materials and, of course, new designs. Morphing machines and tools as enablers of top-down fabrication methods, some considered during the Milgo Experiments, are real possibilities. Continuous methods of fabrication (aeolian, fluvial) to achieve seamlessness in form will continue to be an attractive area for future designers. So will self-shaping, achieved by external agents like force and other physical or chemical phenomena and without the prescriptive use of 3D digital models or use of standard forming methods. Gravity will continue to challenge macro-scale self-assembly of parts requiring new inventions in morphing matter to permit self-adjustment in the parts with increase in size for improved economy of material and hence its conservation. The bottom-up and top-down fabrication of physical form will continue to become more integrated forcing a greater interconnection between disciplines at different scales – macro, micro, nano - and make them seamless. The distance between architecture and synthetic biology will continue to shrink.

A universal morph-code to build shaped matter at different scales will draw from the afore-mentioned periodic table of form. Its encoding in DNA characters (A,T,C,G) will be useful for DNA-built forms and structures and will help make the digital and biological become inter-changeable. The transcription of morph-code via DNA to build at larger scales will continue to be a challenge. Exciting early developments in this direction are coming from nano-scale synthetic biology, especially DNA origami and

INTERVIEW CONT.

its offshoots. The fuller integration of the morph-code with DNA will mark a transformational step in the integration of mathematical form encoded by DNA and grown by genetically engineered microorganisms. A universal morph toolkit, parallel to the gene toolkit discovered by evo devo (evolutionary developmental biology) scientists, would be a significant development to build forms and structures at different scales. This will emphasise process over form, as we did in Xurf series. For DNA encoding, this will mean encoding forms as well as processes. A similar principle will apply at higher scales using physical (non-DNA) technologies.

DNA technology in architecture will come with the usual concerns of ethical, bio-hazard or bio-terrorism issues. This will direct us to look for alternatives to DNA and into non-DNA based coding. One exciting area is pre-biotic (pre-DNA, pre-RNA) technologies which deal with abiogenesis, the origin of life. When discovered or invented, future abiotic technologies will tie us back to our origins. A return to our origin would be a comforting result from our great adventures, a gift from nature, which will tie our future with our deep past inextricably.

To answer your last question, by definition, all in the field of space structures are interested in future building technologies. There will always be pleasant surprises at Spatial Structures 2021.

SOME RELEVANT LINKS

Pratt Institute – Haresh Lalvani

Pratt undergraduate architecture – Digital futures

Lalvani studio

TEDxBrooklyn 2010 – Haresh Lalvani

REFERENCES

[1] H. Lalvani, Genomic Architecture, in: D. Gans, Z. Kuz (Eds.), Org. Approach to Archit., AD Book, Academy-Wiley, 2003. http://lalvanistudio.com/wp-content/uploads/2014/03/AD2003_reduced.pdf (accessed August 24, 2020).

[2] H. Lalvani, Morphological Universe: Genetics and Epigenetics in Form-Making, Symmetry Sci. Cult. 29 (2018). http://journal-scs.symmetry.hu/issue-content/?volume=29&issue=1 (accessed August 24, 2020).

[3] H. Lalvani, 4D-Cubic Lattice of Chemical Elements, Found. Chem. 22 (2020) 147–194. https://rdcu.be/b6cju (accessed August 24, 2020).

[4] H. Lalvani, Meta Architecture, in: S. Perella (Ed.), Archit. Des. - Hypersurface Archit. II. (1999) 32–37. http://lalvanistudio.com/wp-content/uploads/2014/03/AD1999_reduced.pdf (accessed August 24, 2020).

[5] H. Lalvani, Meta Architecture, in: G. Di Christina (Ed.), Archit. Sci., AD Book, Academy-Wiley, 2001.

[6] M. Carpo, Pattern Recognition, in: Metamorph 9, Int. Archit. Exhib. FOCUS. La Bienn. Di Venezia, Venice, 2004. http://lalvanistudio.com/wp-content/uploads/2020/08/Carpo-Pattern-Recognition-2004-E.pdf (accessed August 24, 2020).

[7] H. Lalvani, Multi-Dimensional Periodic Arrangements of Transforming Space Structures, PhD Thesis, University of Pennsylvania, 1981.

* Note that web addresses from the 'some relevant links' section and from hyperlinks were accessed on: August 2020.

Contact us

MoversandShakers@surrey.ac.uk

Spatial Structures Research Centre,
Department of Civil and Environmental Engineering,
University of Surrey

The Spatial Structures Research Centre (SSRC) of the University of Surrey was founded by Professor Zygmunt Stanislaw Makowski in the Department of Civil and Environmental Engineering in 1963. The core aim of SSRC has been conducting research in the design, analysis and construction of spatial structures. Also, education of spatial structures has been at the centre of its ethos over the past six decades. Many different activities have been organised by the Centre over these almost 60 years, in areas such as research, publication, teaching, organisation of conferences, as well as, consulting work.

UNIVERSITY OF SURREY