The Voice of the Systems

The Journal Of The Israeli Systems Engineers

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The 10th Israeli International Conference on Systems Engineering
26-28 March 2019 | Daniel Hotel Herzliya

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Prof. Amir Tomer, Kinneret College - Conference General Chair

Amir Tomer is the head of the software engineering department at Kinneret College on the sea of Galilee. Previously he held various managerial and technical positions in Software and Systems Engineering at RAFAEL – Advanced Defense Systems, for over 25 years. For the last 24 years he has been a senior lecturer at the Computer Science Faculty and the Systems Engineering Master's program at the Technion, Haifa, and to industrial workshops. Amir was the first person in Israel to be awarded INCOSE's CSEP certification.

Mr. Garry Roedler, INCOSE President

Garry Roedler is a Senior Fellow and the Engineering Outreach Program Manager for Lockheed Martin. His systems engineering (SE) experience spans the full life cycle and includes technical leadership roles in both programs and business functions. He is the President of the International Council on Systems Engineering (INCOSE).

Prof. Edward F. Crawley, Ford Professor of Engineering, MIT USA - Keynote speaker

Edward Crawley is the Ford Professor of Engineering at MIT. From 2011 to 2016 he served as the Founding President of the Skolkovo Institute of Science and Technology, Moscow, a new university focused on science and innovation. Prior to that he served as the Director of the Bernard M. Gordon – MIT Engineering Leadership Program, an effort to significantly strengthen the quality of engineering leadership education for competitiveness and innovation. From 2003 to 2006 he served as the Executive Director of the Cambridge – MIT Institute, a joint venture with Cambridge University, funded by the British government and industry, with a mission to understand and generalize how universities act as engines of innovation and economic growth. For the previous seven years, he served as the Department Head of Aeronautics and Astronautics at MIT.

Matthew Hause, Engineering Fellow, PTC, USA - Tutorial Lecturer

Matthew Hause is an Engineering Fellow at PTC, is a member of the OMG SysML specification team, and the co-chair of the UPDM group. He has been developing real-time systems for over 35 years. He started out working in the Power Systems Industry, and has been involved in Process Control, Communications, SCADA, Distributed Control, military systems and many other areas of real-time systems.

Prof. Vincenzo Piuri, University of Milan - IEEE Systems Council President - Tutorial Lecturer

Vincenzo Piuriis a Full Professor in computer engineering (since 2000) and Director of the Department of Information Technology at the Università degli Studi di Milano, Italy. His main research and industrial application interests are: intelligent systems, pattern analysis and recognition, machine learning, signal and image processing, intelligent measurement systems, industrial applications, distributed processing systems, IOT, cloud computing, fault tolerance.He founded a start-up, Sensuresrl, in the area of intelligent systems for industrial applications and was active in industrial research projects. He is Fellow of the IEEE, Distinguished Scientist of ACM, and Senior Member of INNS.

Dr. Avigdor Zonnenshain, Gordon Center for SE, Technion - Tutorials Day Chair

Avigdor Zonnenshain is currently a Senior Research Fellow at The Gordon Center for Systems Engineering at the TECHNION, Israel Institute of Technology. Formerly, he held several senior positions at RAFAEL in Quality & Reliability Management & Engineering, in Project Management & Systems Engineering. Dr. Zonnenshain is a former President of the Israeli Society for Systems Engineering - INCOSE_IL and now he is an active member in the management of the organization. Dr. Zonnenshain is a Fellow of INCOSE.

Dr. Ram Oron, INCOSE_IL President – tour day chair

Ram Oron received his Ph.D. in physics from the Weizmann Institute of Science in the field of lasers. In early days of his career he served as a system engineer at IAI. Later, he was one of the founders and CTO of KiloLambda, a start-up company in the field of optics. In the last 11 years, Ram is with Orbotech, leading system engineering and physics activities in the development of several multi-disciplinary systems. Ram is active in the system engineering community, and since 2017 he serves as the president of the Israeli Chapter of INCOSE.

INCOSE_IL 2019 - Complete invitation on page 14

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חלקו העברי של הגליון נמצא מצידו השני

The Voice of the Editor

Prof. Amir Tomer, CSEP

Dear Readers,

The 23rd issue of The Voice of the Systems is published, as usual, at the day of the bi-annual systems engineering day at Gorgon Institute at the Technion. This day is dedicated to innovation in systems engineering as a response to the scaling up challenge of system complexity. This topic is also at the heart of the tenth international conference of the Israeli association of systems engineering - **INCOSE_IL 2019**, which will be held on March 26-28 under the title **Smart Engineering for Smart Systems**. As I am honored to serve as the conference chair, please allow me to personally invite you to participate. The detailed conference agenda is found in this issue.

A new Israeli Chapter of IEEE Systems Council has been established recently. It will operate under the Israeli Chapter of IEEE Israel and will be chaired by Dr. Yaniv Mordecai of Motorola, Israel, who initiated it. In this issue you will find a description of the background and operation of this new chapter, written by Yaniv.

Also included in this issue are three articles written by presenters at the Gordon Center's systems engineering day: Prof. David Saad describes the challenges of modern interconnected complex systems, Eran Reuveni details 20 paradigms comprising the philosophy of engineering and Arnon Katz proposes an implementation of a systemic concept as a multiplier for success in technological entrepreneurships.

I wish you pleasant reading.

Prof. Amir Tomer, CSEP
Kinneret College
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The Voice of INCOSE_IL President

Dr. Ram Oron

The Israeli Society for Systems Engineering

Dear Systems Engineering Community,

We are concluding another year of extensive activity. This includes maintaining and improving existing activities and entering new activities and areas. Among these, are activities in the system engineering leadership domain, and system engineering exposure activities for high school students (by more than ten volunteers from our community). In the international arena, about 10 of us attended the INCOSE IS conference in July in Washington, DC. Some of us took active part as presenters (and for those who did not participate, I recommend reading the summary in this journal). We were also awarded the Silver Chapter Circle Award for our chapter activities in 2017.

In June, the system engineering TAU-SERI project was launched at the Tel Aviv University. The project is planned to engage in basic and industry related research in the field of system engineering, as well as to include a track of graduate studies. I believe this is significant to our community, as another leading university is entering the field of systems engineering. We wish the project success, and hope that it would become an additional and significant layer of academic activity in the field of systems engineering.

As we enter 2019, we are in the final preparation stages towards the 10th International Israeli System Engineering Conference, that will take place in Herzliya in March. The conference will include lectures, panels, and seminars, with leading Israeli and international professionals. The conference chairman, Prof. Amir Tomer, and I, are looking forward to your participation in the event and contribution to its success.

Sincerely,

Dr. Ram Oron
President, INCOSE IL
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Challenges of modern interconnected complex systems

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Introduction

The deluge of available data, growth in computer power and the increasing interconnectedness at all levels offer great promise for the improvement of services, better use of resource, increased automation and higher efficiency. We enjoy unprecedented access to data, harvested from sensors, monitors and information/social networks, as well as uninterrupted connectivity between individuals, between infrastructure systems and soon, between household appliances.

While offering great potential in the exploitation of data for the design, management and optimal use of resource, the interconnectedness and amounts of data available pose significant challenges and exposure to risks. This is particularly true for the main infrastructure systems such as power and water networks, traffic systems, logistic supply chains and information and communication networks, both wired and wireless.

The characteristics of modern complex systems are their large scale, nonlinearity, heterogeneity, variable connectivity and volatility, all of which make the analysis and management of such systems increasingly difficult. Moreover, even in each system on its own these features may lead to emergence behaviour and cascading failures; the risk is exacerbated due to the cross-links and inter-dependence between systems, for instance, a failure in information and communication systems could have devastating effects on transport, power and water networks.

Challenges

The main challenges in gathering data, analysing it and exploiting it for better design and management of large scale interconnected systems are as follows:

- **Data harvesting -** Monitoring and data gathering sensors should be placed in key locations in order to gather as much useful data as possible, to be used for both analysis and management. The nonlinearity and connectedness of existing complex systems make it more difficult to identify the best locations for placing sensors and monitors such that the tale tell signs of important events would be captured. This relates, for instance to the deployment of sensors in road networks, optical communication networks etc.
- **Data analytics -** The amount of data and variability in its relevance present a formidable analytical and computational challenge. The sheer amount of data, the nonlinearity and complexity of the systems and their volatility, require the development and use of principled approximate methods for analysing data, inferring system states and for extracting useful information. This is true in most large-scale systems, such as transport, optical communication and the electricity grid, where measurements are noisy and the statistical inter-dependence between measurements is not clear a priori.

- **Management and control -** The allocation of resources, the choice of system operational parameters and the identification of evolving patterns are key questions in the management of modern interconnected systems. They become much more difficult by the system volatility and connectedness. This is also partly due to the need to optimise and do more with less, as resources are depleted and national, social and environmental pressures are mounting; and partly due to the severe consequences of dramatic failures since optimised interconnected systems operate with little or no spare capacity and failures can trigger chain events.
- **Design -** While in many cases the systems comprise both legacy and new components, some sectors of large systems may be designed and deployed afresh, primarily to address changing circumstances, to incorporate new technology or to add new capabilities. In other cases, changes are introduced systematically to existing systems in order to improve their operation. In either case, in the absence of better analytical tools, common practice is to use simulation techniques to predict the expected performance and perfect the design; for instance, when new roads, bridges or tunnels are added to the existing road network. There are significant limiting factors to this approach, both in terms of the huge cost of tailored large-scale simulations and the limited number of cases covered.
- **Intuitive understanding -** We are currently at a cross-road where increasingly more authority is given to machines through artificial intelligence and machine learning-based algorithms. More often than not, the answers provided from these machines are hard to interpret and the specialist is hand-waving in an attempt to explain the result. While in many cases we accept the machine recommendation, the latter may be misleading, non-informative or simply wrong. New tools should be used to interpret the results in an intuitive manner that could be understood by decision-makers, controllers and designers. This typically involves the mapping of multidimensional data onto the two/three dimensions. For instance, it would be good to have a visual representation on how close we are to the envelope of valid operational conditions in the electricity grid or transportation networks in order to take a corrective action.
- **Prioritisation and biasing user behaviour -** It is clear that not all services could be provided all the time and that measures should be taken to moderate demand and/or minimise service disruption. This constitutes two separate challenges: **1)** How can one bias the behaviour of individuals through penalty/reward to align the selfish rational decision with the global optimum. Examples for such mechanisms are the application of variable road-toll or electricity tariffs according to congestion/demand in the corresponding systems. **2)** Regulating services and/or reducing the quality of service such that some utility function is optimised. For instance, allowing for the transmission of very large packets (termed "elephants") through the internet only at times of low demand, or violating the principle of net neutrality. The former is already practiced by main optical communication providers, such as BT in the UK, to ensure quality of service.

Risks

The interconnectedness, volatility, nonlinearity and lack of spare capacity increase the risk of failure in large scale systems. In particular:

- **Volatility -** The volatility of many modern infrastructure systems poses a significant risk due to the unpredicted nature of resources and/or demand. Volatility on its own, when sources are uncorrelated random variables, can be addressed by adding resource, based on an appropriate noise/uncertainty probabilistic model and a quality-of-service constraint; for instance, adjusting the extra resource in power networks

such that only a small percentage of demand that corresponds to the tail of a Gaussian will not be provided. However, in many cases the source of the volatility is correlated random variables that are much more difficult to deal with. For instance, many of the renewable energy sources are weather dependent and are therefore statistically dependent; vehicular and communication traffic can increase dramatically due to specific events.

- **Destabilising modes -** The complexity, nonlinearity and interconnectedness of systems may lead to the development of non-trivial destabilising modes that could result in cascading failures. The onset of destabilising modes from a specific distributed set of fluctuations in the system(s) can gather pace in a manner that will bring down part of the system and/or a number of coupled infrastructure systems. For instance, specific fluctuations in electricity demand and production due to correlated volatility in weather conditions may trigger a localised peak in demand that could spread at the transmission-grid level and result in a large-scale blackout. Identifying the tell-tale signs of destabilising modes before they push the system outside the envelope of valid operational conditions is highly challenging but of great significance in many complex systems.
- **Spreading processes -** Failures and detrimental operating conditions in complex systems are often represented by a stochastic spreading process, akin to epidemic spreading. For instance, failure processes in a power plant may "infect" neighbouring plants through the transfer of excess load, leading to a spreading failure; similar processes are observed in transport and optical communication networks. One of the main challenges is to find principled ways to contain the spread and protect the system from a wide-spread failure, but in a manner that minimises the disruption and inconvenience to users.
- **Rare events -** While most planning is carried out for normal operation conditions, one must also plan for rare events in the form of emergencies or unexpected disruptions. The planning for atypical system conditions is particularly difficult as it is hard to anticipate and address all eventualities. Moreover, in many cases solutions should be provided in real time and hence should be carried out with limited computational costs. This does require having spare capacity, but more importantly the development of inherent robustness in the system and agility in adapting solutions to a changing environment. Spare capacity at the design level can mitigate some of these risks but not all; approximate methods that can address changing conditions, such as road network alterations due to accidents or fire, in real time are needed.

Approach

The approach I advocate for addressing these challenges and mitigating the risks relies mostly on principled probabilistic approaches from the general area of machine learning and Bayesian methods. The particular variants I have been investigating are based on distributed methods where global solutions are obtained through passing probabilistic messages between the system's components.

Exemplar systems

To demonstrate some of the challenges and risks in having interconnected large-scale and volatile systems, I have chosen to focus on specific problems in two major infrastructure systems, vehicular transportation and the electricity grid. However, many other systems suffer from the same problems and are exposed to similar risks, for instance, logistics networks and communication and information systems, both wired and wireless.

Vehicular transport

Improving the management of road traffic has substantial and direct impact on the economy and general well-being of the public; for instance, the UK economy is expecting an overall increase in the annual cost of road congestion, rising from $20.5B in 2013 to an expected $33.4B in 2030. Global traffic management will become more feasible through improved monitoring, on-line information provision, monetary incentives and the expected penetration of autonomous cars and haulage into the market.

One of the areas I have been investigating, global routing, has consequences for better use of resource, reduction in energy consumption and in the emission of greenhouse gases. Increases in road traffic imply long term and massive investment in new expensive infrastructure; the latter is not only costly but has environmental impact, requires long term planning in a fast developing and unpredictable environment.

Due to the assumption that selfish-routing decisions lead to (Nash-like) Wardrop-equilibrium and the hard-computational nature of the global routing problem, most existing routing algorithms rely on selfish localised decisions to find the shortest weighted path to destination based on past or recent data. A global approach that takes into account all individual path decisions is crucial for the efficient use of an already over-stretched infrastructure. With the increasing penetration of route planners, selfish routing choices may become counterproductive even at the individual level due to the emerging effective correlations between selfish individual choices. For instance, numerical work in the area of vehicular routing on the DynaMIT simulator at MIT, shows that above a certain percentage of penetration, the usefulness of route planners (for their users) deteriorates rapidly.

Moreover, routing algorithms should have the flexibility to accommodate different costs reflecting different objectives. For instance, in many cases one would like to suppress congestion by minimising overlaps between routes, attributing weights to roads/junctions to reflect preference, capacity or delays. At the other end of the spectrum, one may use objective functions aimed to decrease the number of active junctions/roads by consolidating paths to reduce demands (policing, gritting, man-power, etc).

The routing task, termed Dynamic Traffic Assignment, aims to optimise routes between origins and destinations on a graph; it is currently solved primarily by linear and convex programming. As realistic scenarios are inherently non-linear and complex, other approaches have been suggested. Among the promising approaches used are variational inequality, optimal control, congestion pricing, differential games and space-time network. Some of these approaches have been embedded in complete development suites such as SATURN and Cube. Typically, the dynamics and interaction between vehicles are described by a set of dynamics equations, which are then solved by conventional inference/optimisation methods. These approaches usually do not accommodate uncertainty, incremental adaptation and flexibility in their formulation and objectives and may suffer from multiple sub-optimal solutions characteristic of complex systems.

An important aspect of the interplay between selfish and globally-optimal routing is in the ability to influence rational decisions of individuals in order to benefit all. Inducement measures for influencing the decisions of individuals already exist in various countries[2] and take a variety of forms, such as adaptive toll roads, lane-reassignments and speed-limits, but are typically applied in a heuristic and intuitive manner on the basis of off-line simulations.

A message-passing based approach for routing,, we have been working on can potentially accommodate uncertainties, prior knowledge and probabilistic data as well as various objective functions (both convex and concave); help quantify the effect of selfish routing and devise principled algorithmic tools to adaptively influence users into making rational selfish decisions that are aligned with the global optimum; provide tools to the design of optimal travel routes for major events (e.g., a football game), controlled tasks (haulage, logistics and transport operations) and day-to-day traffic.

Electricity grid

Future electricity networks are expected to have different characteristics from existing transmission and distribution networks mainly due to changes in the portfolio of energy sources and consumption profile; both are also influenced by government policy, changing availability of resource and attempts to pro-actively influence demand patterns. Electricity networks will be much more unpredictable, volatile and difficult to control, so there is a requirement for new tools to manage, optimise and control power networks in real time which can also be used to improve resilience and robustness by detecting and preventing network instabilities.

It is difficult to overstate the economic impact of optimising the future power network. Currently the annual cost of power losses in the USA is estimated at $30B. The cost of the 2003 US blackout was $7-10B and the total cost of blackouts annually in US is $80B. The future power network is likely to be more complex and prone to losses with much stronger emphasis on carefully managing dwindling resources, making this work highly timely.

The new challenges are directly linked to the planned increase in contribution from micro and medium-size generators, such as wind turbines, Combined Heat and Power (CHP), photo-voltaic panels etc. Large wind farms and up to 8 million micro-generators are expected to be connected to the national grid in the UK by 2020. One of the main challenges will be the difficulty in controlling the grid with much greater volatility in production and demand and a stronger correlation between producers and consumers. It will be possible to achieve quality of service targets with a much greater dependence on intermittent natural phenomena, such as wind, solar radiation, tide and temperature (i.e. only under operator control to a limited extent), combined with greater reliance on nuclear power running in steady state (i.e. cannot respond to changes in demand), only with smart network and demand management. Moreover, the inherently hierarchical and heterogeneous structure of electricity systems combining mostly tree-like structures for low-voltage networks, mostly densely connected structures for high voltage and a mixture of both for medium-voltage networks raises additional difficulties. The expected increase in the share of renewable energy sources, if managed by existing methods, may result in interruptions to the provision of electricity. The introduction of correlated random variables (forcings) also exposes the power grid to new types of instabilities, which will result in an unwanted requirement to increase generating capacity in order to safeguard against fluctuations in production and demand.

Some of the main challenges in the future power network include:

A. Optimising the utilisation of a portfolio of energy sources for a specific task and level in the hierarchical network topology with respect to some quality measure, taking into account the expected power generation and consumption as well as inherent pre-specified constraints (e.g., voltage range, AC frequency). This is aimed at minimising load-shedding and losses while avoiding over-production.

B. Determining the distance to failure (e.g. exceeding voltage limits) of given operating conditions and actions that should be taken to increase it. This should also provide intuitive and informative description of the state of the system to controllers and decision makers. c) Identifying destabilising modes of operation in the network and detecting key indicators for their onset. This is critical for the development of cascading failures that may result in large scale blackouts and impact on other services and the infrastructure systems. This is mostly an uncharted territory and a formidable task. d) Containment of a cascading failures by disconnecting or protecting sensitive power plants is akin to the vaccination process in an epidemic spreading scenario. New tools should be employed to identify the best times and locations for the deployment of protective measures.

Most existing methodologies20 are unable to meet the challenges of future power networks:

I. They are based on the iterative solution of coupled differential and algebraic equations, which give little insight into the limitations and characteristic behaviour of large-scale networks. Moreover, while operating at the millisecond level, these methods have little ability to deal in real time with the volatile correlated random variables of future power networks. Decisions in many sub-stations are currently taken locally and heuristically with little consideration of their global impact.

II. A prohibitively large number of simulation runs is required to define the envelope of valid operational conditions, rendering it infeasible in practice for large-scale networks. Robustness is estimated by simulating the removal of single energy plants/producers from the network. These are crude approaches and are limited in dealing with random variables as different definitions and robustness measures apply when a substantial fraction of the producers/consumers are represented by correlated random variables. In this case, it is much more important to identify unstable modes of operation and indicators of their onset that cannot be detected merely by the removal of single components.

III. Finally, the current method, involving maximum load/minimum generation and minimum load/maximum generation, is wasteful, and leads to an overly expensive infrastructure, which is likely to be unsustainable. Since generators and consumers increasingly behave as correlated random variables such a method will require an increase in generation capacity to cope with larger fluctuations, defeating the objective of replacing conventional sources by renewables and wasting precious resources that are likely to be scarcer in years to come. More sophisticated approaches, based on the application of statistical physics and probabilistic methodology have been suggested, but many questions have not been fully addressed, such as correlations, emerging instabilities and methods to identify and control them.

Suggested methodology

It is clear that future systems are expected to be highly interconnected, of large scale and fluctuating. It will be difficult to run each one of them, let alone a framework that encompasses all of the interactions between them, in a localised piece-wise manner. The methodology to analyse, design and manage them should therefore be of a probabilistic nature (to address the volatility issue), distributive (addressing the large-scale aspect), holistic (to identify emergence phenomena) and principled (such that the limitations of the results obtained are clear).

Data driven machine learning methods are likely to play a major role in the understanding, design and management of the systems of the future. Advances in heuristic and principled machine learning techniques offer promising directions. The methods I advocate using are based on Bayesian approaches but also are deeply rooted in theoretical statistical physics.

More specifically, Bayesian approaches allow for probabilistic modelling of data in a parametric and semi-parametric manner, for regression and classification, for inference and global optimisation of systems on the basis of localised messages passed between network constituents, for the extraction and presentation of the most informative projections of the data on two/three dimensions and much more. Many of the methods offer principled approximations that are computationally efficient and grow linearly or quadratically with the system size; they facilitate near real-time applications and typically provide expected values as well as the corresponding error-bars. In the following I am going to mention a small number of methods, many more exist in the literature[26,27,28].

Regression: Gaussian processes offer a reliable tool for modelling probabilistic functional dependence on the basis of data; they work very well for low-dimensional data and provide both expected values and value dependent error-bars. Training requirements grow cubically with the data size (or quadratically if trained iteratively). However, computational cost of expectation values and variances grow linearly with data size.

Message passing: Many design questions on sparsely-connected networks can be addressed algorithmically, using message-passing techniques by assigning an objective-function based probability, and obtaining an approximation to the marginal posterior maximiser for the network variables by passing probabilistic messages between network constituents; when the messages converge the marginal probabilities can be calculated. These methods are localised, computationally efficient and are exact on tree-like networks, although they work successfully on general networks that are locally tree-like or densely connected.

Visual informatics: To classify and present the state of the system in the most informative way one can employ informatics visualisasion methods such as Generative Topographic Mapping, Neuroscale, Factor Analysis and Principal Component Analysis[26,27,28]. These methods enable one to present data in two dimensions after linear or nonlinear transformation, along the most informative and relevant axes, pointing to a measure of significance; for instance, highlighting the minimal distance to system failure. Visual informatics methods will also be used to classify the different operating conditions. The generated representation is intuitive and easier to understand.

Conclusion

Modern interconnected and complex infrastructure systems offer great opportunities which also involve substantial risks. We must develop and employ the right mathematical and analytical tools to exploit these opportunities fully, while making sure that their operation is sufficiently robust to allow for a smooth operation at normal-day scenarios as well as under atypical conditions such as emergencies and unusual demand.

Acknowledgement

Many of the concepts presented here regarding large-scale interconnected systems have resulted from discussions over many years with Eran Reuveny. The mathematical approaches presented should be complemented by addressing the corresponding engineering challenges, which will be the focus of a follow-up paper. I would like to thank the Leverhulme Trust (RPG-2018-092) and the EPSRC Programme Grant TRANSNET (EP/R035342/1) for their support.

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1. Centre for Economics and Business Research http://www.cebr.com/reports/the-future-economic-and-environmental-costs-of-gridlock/.
2. http://www.theguardian.com/business/2014/dec/07/gps-smart-card-open-data-used-reduce-transport-congestion
3. J.G. Wardrop, J.I. Whitehead, ICE Proceedings: Eng. Divisions 1, 767(1952).
4. R.M. Garey and D.S. Johnson, Computers and Intractability, Freeman (1979).
5. R. Balakrishna et al, Transportation Research Board, 1910, 90 (2005).
6. S. Peeta, and A. K. Ziliaskopoulos, Networks and Spatial Economics 1, 233 (2001).

7. D. K. Merchant and G. L. Nemhauser, Transportation Sci. 12, 200 (1978).
8. H. Bar-Gera, Transportation Sci. 36, 398 (2002).
9. Y. Xiang et al, Proc. of European Transport Conf. (2009).
10. M. Carey, Operations Research 35, 58 (1987).
11. T. L. Friesz, et al, Operations Research 37, 893 (1989).
12. M. Carey, in Urban Traffic Networks: Transportation Analysis, ed. N.H. Gartner, Springer-Verlag, 333 (1995).
13. M.G.H. Bell, C. Cassir, Transportation Res. B 36, 671 (2002).
14. M.C.J. Bliemer and P.H. L. Bovy, Transportation Res. B 37, 501 (2003).
15. http://www.saturnsoftware.co.uk/ ;http://www.citilabs.com/software/products/cube
16. C.H. Yeung, D. Saad, Phys. Rev. Lett. 108, 208701 (2012).
17. K.Y.M. Wong, D. Saad, C.H. Yeung, The Inst. of Elect., Inf. and Comm. Eng. (IEICE) Trans, E99-B 2237 (2016).
18. C.H. Yeung, D. Saad and K.Y.M. Wong, Proc. National Academy Sci. of the USA 110, 13717 (2013).
19. D. J. C. Mackay, Sustainable Energy – Without the Hot Air, UIT, Cambridge (2008).
20. H.W. Dommel and W.F. Tinney, IEEE Trans. On Power Apparatus and Systems 10, 1866 (1968).
21. E. Harrison, D. Saad, and K.Y. Michael Wong, Energy Procedia 107, 101 (2017).
22. M. Chertkov et al, IEEE Trans. on Smart Grids 2, 150 (2010).
23. A.Y. Lokhov and D. Saad, Proc. National Academy Sci. of the USA 114, E8138 (2017).
24. R. Pfitzner et al, Proc. of IEEE PES (2011).
25. F. Dorfler, M. Chertkov and F. Bullo, Proc. National Academy Sci. of the USA 110, 2005 (2013).
26. C. Bishop, Pattern Recognition and Machine Learning, Springer (2006).
27. D. Barber, Bayesian Reasoning and Machine Learning,Cambridge University Press (2012).
28. K. Murphy, Machine Learning: A Probabilistic Perspective, MIT press (2012).
29. M. Mezard and A. Montanari, Information, Physics and computation, OUP, UK (2009).
30. C.E. Rasmunssen and C.K.I. Williams, Gaussian Processes for Machine Learning, MIT press (2006).

David Saad holds the 50th Anniversary Chair of Complexity Physics and is Head of Mathematics at Aston University, Birmingham UK. He received a BA in Physics and a BSc in Electrical Engineering from the Technion, Haifa, Israel (1982), an MSc in Physics (1987) and a PhD in Electrical Engineering (1993) from Tel-Aviv University. He joined the Physics Department at the University of Edinburgh in 1992 and Aston University in 1995. His research, published in over 200 journal and conference papers, focuses on the application of methods from statistical physics and Bayesian statistics to a range of fields, which include neural networks, error-correcting codes, multi-node communication, network optimisation, routing, noisy computation, epidemic spreading and advanced inference methods.

Implementation of a Systemic Concept as a Multiplier for Success in Technological Entrepreneurships

[Abstract]

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The success rate of technological entrepreneurships in Israel is around 4%, and has been similar for many years. This relevance should be questioned, as an approach based on systemic thinking doubts its' real necessity and claims that the possible success rates can be more than doubled, utilizing the correct and suitable concept.

Vast experience in the field, a longtime acquaintance with systems and practical utilization of the holistic approach initiated a qualitive research supported by the Gordon Center for System Engineering at the Technion. The original perception was questioned versus many references and verified by professionals, including interviews with acknowledged experts in the field of technological entrepreneurship and start-ups. All lead to the same conclusion: Implementation of a systemic concept and embedding a suitable practical approach can improve drastically the success rates. The article refers to the research results, emphasizing the main failure and success factors, their interaction, synergy and reciprocal reliance.

The complete article is on **page 1** of the hebrew side of the issue.
המאמר המלא נמצא בחלקו העברי של הגיליון

The Philosophy of Engineering

[Abstract]

Eran Reuveni, The Transportation Research Center, Technion
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The **philosophy of engineering** is an emerging discipline that considers what is engineering, what engineers do, and how their work impacts society. As such, the philosophy of engineering includes aspects of ethics and aesthetics, as well as the ontology, epistemology, etc. that might be studied, for example, through the philosophy of science.

Engineering is the profession aimed at modifying the natural environment, through the **design, manufacture and maintenance** of artifacts and technological systems. It might then be contrasted with science, the aim of which is to understand nature. Engineering at its core is about causing change, and therefore management of change is central to engineering practice. The **philosophy of engineering** is then the consideration of philosophical issues as they apply to engineering. Such issues might include the objectivity of experiments, the ethics of engineering activity in the workplace and in society, the aesthetics of engineered artifacts, etc.

One of the characteristics of engineering is the requirement for the engineer to make quantitative predictions of the behavior and effect of the artifact prior to its manufacture. Such predictions may be more or less accurate but usually includes the effects on individuals and/or society. In this sense, engineering can be considered a social as well a technological discipline and judged not just by whether its artifacts work, in a narrow sense, but also by how they influence and serve social values. What engineers do is subject to moral evaluation.

The "classic engineering approach" makes elaborate attempts to ensure that the design engineering solution meets its specifications and other requirements prior to its actual construction. Systems Modelling and Description makes an effort to extract the generic unstated principles behind the such engineering approach.

The traditional engineering disciplines seem discrete, but the engineering of artifacts has implications that extend beyond such disciplines into areas that might include psychology, finance and sociology. The design of any artifact will then take account of the conditions under which it will be manufactured, the conditions under which it will be used, and the conditions under which it will be disposed. Good Engineering practice should consider "system life cycle" issues.

Socio-technical systems, such as transport, utilities and their related infrastructures comprise human elements as well as artifacts. Traditional mathematical and physical modeling techniques may not take adequate account of the effects of engineering on people, and culture.

In this article we propose a set of 20 phrased paradigms. This set of paradigms is a result of an long term effort to extract the generic unstated principles behind the engineering in wide sense of the ward and it is proposed as a starting point of open discussion regarding each paradigm.

The complete article is on **page 7** of the hebrew side of the issue.
המאמר המלא נמצא בחלקו העברי של הגיליון

Foundation of the IEEE Systems Council Israel Chapter

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ymordecai@gmail.com

In March 2018, the Board of INCOSE IL decided to facilitate collaboration with peer associations such as IEEE Israel and the Israeli Chamber of Information Technology. IEEE is the world's largest technical professional organization dedicated to advancing technology for the benefit of humanity. The IEEE Israel Section was established in 1954, and is the oldest IEEE section in Region 8 (Europe, The Middle East, and Africa). Currently, IEEE has over 1300 Israeli members, active in 15 chapters.

The IEEE Systems Council was founded by the IEEE Board of Directors in 2005 to address cross-cutting systems-level problems and challenges, such as Systems Engineering education, standards, processes, methodologies, systems architecture, modeling, simulation, integration, resilience, robust design, human factors, safety, security, usability, mission assurance, requirements development & management, and risk management. The council overarches ten major IEEE societies: Aerospace & Electronic Systems Society (AESS), Circuits & Systems Society (CAS), Communications Society (ComSoc), Computer Society (CS), Instrumentation and Measurement Society (I&M), Microwave Theory & Techniques Society (MTT-S), Power Electronics Society (PELS), Product Safety Engineering Society (PSES), Robotics & Automation Society (RA), and Systems, Man, and Cybernetics Society (SMCS).

The IEEE Systems Council publishes the appraised IEEE Systems Journal and conducts two annual systems engineering conferences: Systems Conference (SysCon) and International Symposium on Systems Engineering (ISSE). In addition, the council houses Technical Committees (TCs) on cross-cutting topics such as: Intelligent Transportation, Security & Privacy, Cyber-Physical Systems, and Human-System Integration. The Systems Council collaborates globally and locally around the world with INCOSE (International Council on Systems Engineering) and its chapters.

In the IEEE Israel Section's Annual Meeting, held on July 10, 2018, the assembly unanimously supported the formation of an IEEE Systems Council Israeli chapter under the auspices of IEEE Israel. Dozens of IEEE members expressed their support and interest, and a petition submitted to the IEEE was authorized by the IEEE Section Chair, Prof. Uri Shaked, and by the IEEE Systems Council President, Prof. Stephanie White.

The main goals of the IEEE Systems Council Israel Chapter (SysCIL) are:

- Promote participation of Israeli systems engineers in IEEE Systems Council activities;
- Generate awareness among IEEE Israel section members and Israeli engineers in general to the Systems Engineering discipline;
- Constitute a collaboration vehicle between IEEE Systems Council and the INCOSE Israel chapter (INCOSE_IL), in order to generate synergies of systems engineering research, innovation, and practice in Israel and by Israeli researchers around the world; and

Serve as the liaison between the IEEE Systems Engineering community and the Israeli Systems Engineering community.

A festive launch of the IEEE SysCIL will be held during the 10th International Systems Engineering Conference in Israel - INCOSE_IL 2019 - March 26-28, 2019. The IEEE Systems Council President-Elect, Prof. Vincenzo Piuri, will participate in the conference and in the launch ceremony, and will also hold a special tutorial on Internet-of-Things Technology Convergence. In addition, a special IEEE Systems session will be held during the conference, chaired by Mr. Shmuel Auster, IEEE Israel Section Treasurer, in which Israeli researchers will be recite recent works published in leading IEEE Systems outlets (Systems Journal, Systems Conference, etc.).

Dr. Yaniv Mordecai is a senior systems architect in Motorola Solutions, an adjunct lecturer at Holon Institute of Technology, and a research affiliate at Technion – Israel Institute of Technology. He holds a PhD in Information Systems Engineering from Technion (2016), and MSc (cum laude) and BSc in Industrial Engineering from Tel-Aviv University (2010, 2002). Yaniv won the "Exemplary Systems Engineering Dissertation" award from the Omega Alpha Association – Systems Engineering Honor Society (2017), and the "Outstanding Systems Science and Engineering PhD Diploma Work" from the IEEE SMC Society (2017). Yaniv is a member of INCOSE, senior member of the IEEE, and founder of the IEEE Systems Council Israel Chapter.

Dr. Yaniv Mordecai is a senior systems architect in Motorola Solutions, an adjunct lecturer at Holon Institute of Technology, and a research affiliate at Technion – Israel Institute of Technology. He holds a PhD in Information Systems Engineering from Technion(2016), and MSc (cum laude)and BSc in Industrial Engineering from Tel-Aviv University (2010, 2002). Yaniv won the "Exemplary Systems Engineering Dissertation"award from the Omega Alpha Association - Systems Engineering Honor Society(2017), and the "Outstanding Systems Science and Engineering PhD Diploma Work" from the IEEE SMC Society(2017). Yaniv is a member of INCOSE, senior member of the IEEE, and founder of the IEEE Systems Council Israel Chapter.

Applied Systems Thinking: Summary of the Gordon Center Seminar Day, June 16th, 2018

Avigdor Zonnenshain, The Gordon Center for Systems Engineering, Technion
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The Gordon Center bi-annual Systems Engineering seminar day focused this time on applied systems thinking. The keynote speaker was Dr Robert Edson, who demonstrated how to apply systems thinking in modern systems engineering. Several other speakers demonstrated systemic aspects from other different disciplines, such as system analysis, software engineering, data sciences, operation research & systems science, and how systems engineering discipline can learn and apply these other practices for its benefits.

This seminar, in the commemoration of Dr. Zeev Bonen, attracted about 200 systems engineers and other participants from the industry, academia and government.

The feedback for the day was very positive and it supported the ongoing learning and practicing in the following areas:

- Applied and practical systems thinking.
- Integrating systems engineering with other engineering disciplines.
- Integrating information technologies into systems engineering.

The presentations of this day are on the Gordon Center site.

https://gordon-se.technion.ac.il/news-events/bonen-day-19-6-18/

The Israeli Society for Systems Engineering

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Technion Israel Institute of Technology

INCOSE IL 2019

The 10th Israeli International Conference on Systems Engineering

26-28 March 2019 | Daniel Hotel, Herzliya

Smart Engineering for Smart Systems

The Digital Revolution, aka the Fourth Industrial Revolution, is happening around us and the systems developed in the world today become smarter and more flexible and possess a greater variety of capabilities. Smart Engineering for Smart Systemsis the title of **INCOSE_IL 2019** - the tenth international conference of the Israeli Association of Systems Engineers, which will be conducted on March 26-27 in Herzliya, Israel. The main goal of this conference is to focus on the increased sophistication and capabilities of both the systems and the systems engineers who design and construct them.

The INCOSE_IL conference, which is conducted every second year, has become the main event of systems engineering in Israel, which attracts not only hundreds of systems engineers, but is rather appraised and appreciated by the international communities, such as INCOSE and IEEE. Senior representatives of these organization will participate in the conference. Thank to the support of Gordon Center for Systems Engineering in the Technion and the sponsorship of Israeli industry and academia, we succeeded to build an agenda which is rich in contents, up to date and inspiring.

The first day will include a guest talk by **Prof. Edward F. Crawley** from MIT, 15 sessions in five tracks which will include talks and panels in a variety of topics, a professional exhibition and a concluding panel dedicated to the contribution of women to systems engineering.

The second day will include three seminars, delivered by international experts, on topics of systems architecture, model-based systems engineering (MBSE) and the incorporation of advanced technologies, such as AI, IoT and cloud computing, in system design.

On Thursday, March 28th, we will host our precious international guests for a visit to the Israeli industry and academia.

Please consider this as a personal invitation to participate in this interesting conference.

Looking forward to meeting you at the conference,

Amir.

Prof. Amir Tomer
Kinneret College on the Sea of Galilee
INCOSE_IL Chair

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First Day Agenda of the Conference, Tuesday // 26.03.2019

7:45-08:30	Gathering and Registration				
08:30-09:30	**Opening and Greetings:** • Conference Chair • INCOSE_IL President • INCOSE Presidency • IEEE Systems Council President Elect • ILTAM				
09:30-10:10	**Keynote** - Prof. Edward F. Crawley, MIT, USA, Model-Based Concepts and Systems				
10:10-10:45	Exhibition and Refreshments				
# Session	**Hall 1**	**Hall 2**	**Hall 3**	**Hall 4**	**Hall 5**
Morning Session 10:45-12:00	Digital Systems and IoT	System aspects of privacy, security and safety	Model Based Systems Engineering (MBSE) and simulations	Human-Systems Integration (HSI)	INCOSE Session
12:00-12:05	Moving between halls				
Noon Session 12:05-13:20	IEEE Systems	Smart Systems of Systems	Leadership in SE	SE belongs to the Youth	-
13:20-14:20	Lunch Break				
Afternoon Session 14:20-15:35	Learning and adaptive systems	SE in the Digital Age	Product lines in a dynamic and innovative environment	Exhibition presenters	Researches in SE
15:35-15:50	Refreshments				
15:50-17:10	**Concluding Panel** - Systems Engineering. Chair: Dr. Leah Goldin, Golden Solutions				
17:10-17:15	Closing				

Professional experts in INCOSE_IL2019 Conference:

- ***"Architecture Decisions and Concepts"***
  Prof. Edward F. Crawley, Professor of Engineering at MIT, USA
- ***"MBSE"***
  Matthew Hause, Engineering Fellow at PTC, USA
- ***"Artificial Intelligence, IoT and Cloud computing"***
  Prof. Vincenzo Piuri, University of Milano, IEEE Systems Council President-Elect

ORGANIZING COMMITTEE:

- **Prof. Amir Tomer,** Kinneret College, conference chair
- **Dr. Ram Oron,** Orbotech, INCOSE_IL President
- **Mr. Haim Richman,** Elta, IAI
- **Dr. Yaniv Mordecai,** Motorola Solutions
- **Mr. Shmuel Auster,** IEEE Israel BoD Member
- **Mr. Moshe Salem,** ILTAM

The Israeli Society for Systems Engineering | ILTAM User's Association | BMGC | Technion Israel Institute of Technology

Seminars Day Agenda, Wednesday // 27.03.2019

08:30-09:00	Gathering and Registration		
	Hall 1	**Hall 2**	**Hall 3**
Morning Session 09:00-12:45	**Seminar A-1** **Convergence of Artificial Intelligence (AI), Internet Of Things (IoT) and Cloud Computing** Prof. Vincenzo Piuri, University of Milano, IEEE Systems Council President-Elect	**Seminar B-1** **MBSE using SysML** Matthew Hause, Engineering Fellow at PTC, USA	**Seminar C** **"Architecture Decisions and Concepts"** Prof. Edward F. Crawley, Ford Professor of Engineering, MIT
12:45-13:45	Lunch Break		
Afternoon Session 13:45-17:00	**Seminar A-2** **Artificial Intelligence (AI) for Cloud Computing and Internet Of Things (IoT) environments** Prof. Vincenzo Piuri, University of Milano, IEEE Systems Council President-Elect	**Seminar B-2** **Best practices for adopting MBSE** Matthew Hause, Engineering Fellow at PTC, USA	–
17:00	Adjourn		

Conference 2019 Registration for INCOSE_IL

26-28 March 2019, Daniel Hotel, Herzliya

EMAIL: kfir@iltam.org | **TEL:** +927-3-6889214 | **FAX:** +972-3-6889216 | **Web:** www.iltam.org/incose_il2019/eng

- ❑ I wish to register for the conference (please type or print clearly):

  Last Name (Surname): _____ First Name: _____

  Company/ Organization:_____

- ❑ Title: _____ E-Mail: _____

  Telephone Number: _____

- ❑ **I am planning to participate at the Professional tour - 28.03.2019**

  Payment Method: credit card or bank transfer.
  - **For payment by Credit card visit our website:** https://www.iltam.org/incose_il2019/eng
  - **For bank transfer please contact our office at e-mail:** kfir@iltam.org

Conference Fee	$400 USD

Price Includes:

- Participation in the Conference day & tutorial day – including lunch and refreshments
- Participation in the technical tour
- Social Dinner in the 26th

Prices does not Include VAT

The Israeli Society for Systems Engineering | ILTAM User's Association | BMGC | Technion Israel Institute of Technology

CHAIRS & SPEAKERS

Prof. Amir Tomer, Kinneret College - Conference General Chair

Amir Tomer is the head of the software engineering department at Kinneret College on the sea of Galilee. Previously he held various managerial and technical positions in Software and Systems Engineering at RAFAEL – Advanced Defense Systems, for over 25 years. For the last 24 years he has been a senior lecturer at the Computer Science Faculty and the Systems Engineering Master's program at the Technion, Haifa, and to industrial workshops. Amir was the first person in Israel to be awarded INCOSE's CSEP certification.

Mr. Garry Roedler, INCOSE President

Garry Roedler is a Senior Fellow and the Engineering Outreach Program Manager for Lockheed Martin. His systems engineering (SE) experience spans the full life cycle and includes technical leadership roles in both programs and business functions. He is the President of the International Council on Systems Engineering (INCOSE).

Prof. Edward F. Crawley, Ford Professor of Engineering, MIT USA - Keynote speaker

Edward Crawley is the Ford Professor of Engineering at MIT. From 2011 to 2016 he served as the Founding President of the Skolkovo Institute of Science and Technology, Moscow, a new university focused on science and innovation. Prior to that he served as the Director of the Bernard M. Gordon – MIT Engineering Leadership Program, an effort to significantly strengthen the quality of engineering leadership education for competitiveness and innovation. From 2003 to 2006 he served as the Executive Director of the Cambridge – MIT Institute, a joint venture with Cambridge University, funded by the British government and industry, with a mission to understand and generalize how universities act as engines of innovation and economic growth. For the previous seven years, he served as the Department Head of Aeronautics and Astronautics at MIT.

Matthew Hause, Engineering Fellow, PTC, USA - Tutorial Lecturer

Matthew Hause is an Engineering Fellow at PTC, is a member of the OMG SysML specification team, and the co-chair of the UPDM group. He has been developing real-time systems for over 35 years. He started out working in the Power Systems Industry, and has been involved in Process Control, Communications, SCADA, Distributed Control, military systems and many other areas of real-time systems.

Prof. Vincenzo Piuri, University of Milan - IEEE Systems Council President - Tutorial Lecturer

Vincenzo Piuriis a Full Professor in computer engineering (since 2000) and Director of the Department of Information Technology at the Università degli Studi di Milano, Italy. His main research and industrial application interests are: intelligent systems, pattern analysis and recognition, machine learning, signal and image processing, intelligent measurement systems, industrial applications, distributed processing systems, IOT, cloud computing, fault tolerance.He founded a start-up, Sensuresrl, in the area of intelligent systems for industrial applications and was active in industrial research projects. He is Fellow of the IEEE, Distinguished Scientist of ACM, and Senior Member of INNS.

Dr. Avigdor Zonnenshain, Gordon Center for SE, Technion - Tutorials Day Chair

Avigdor Zonnenshain is currently a Senior Research Fellow at The Gordon Center for Systems Engineering at the TECHNION, Israel Institute of Technology. Formerly, he held several senior positions at RAFAEL in Quality & Reliability Management & Engineering, in Project Management & Systems Engineering. Dr. Zonnenshain is a former President of the Israeli Society for Systems Engineering - INCOSE_IL and now he is an active member in the management of the organization. Dr. Zonnenshain is a Fellow of INCOSE.

Dr. Ram Oron, INCOSE_IL President – tour day chair

Ram Oron received his Ph.D. in physics from the Weizmann Institute of Science in the field of lasers. In early days of his career he served as a system engineer at IAI. Later, he was one of the founders and CTO of KiloLambda, a start-up company in the field of optics. In the last 11 years, Ram is with Orbotech, leading system engineering and physics activities in the development of several multi-disciplinary systems. Ram is active in the system engineering community, and since 2017 he serves as the president of the Israeli Chapter of INCOSE.

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