**DESCRIPTION OF THE NEW SCIENCE OF SYSTEMS**

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**Summary**

Practically the whole of human intellectual endeavour has been achieved by the use of qualitative and quantitative properties as opposed to structural properties for the expression of impressions and thoughts. The former properties range from the length of the top of the dining table to the beauty of Mona Lisa or the informative content of a set of first order differential equations describing a capacitance – resistance network. It is the quality and quantity of aspects of a part of the world which are of primary human interest immediately accessible to the senses. The structural property of the table i.e. its four legs are attached to its top, is of more interest to its manufacturer.

The following are consequences of this intense human interest :

**I.** **Question of range**

Due to the wide range of human interest, there is an equally wide range of qualities and quantities to cater for this interest expressed effectively in natural language as ‘adjectival phrases’ qualifying other parts of a sentence of the ‘subject – predicate’ form which is a complete description of a part of the world. We have in the course of every day life and in the fields science, art, politics etc :

Concrete properties : Mechanical like displacement, force, density, electrical like charge and current and so on, others like smooth, salty, long,

Abstract properties : Describing performance like fast, appearance like smart, appreciation such as tasty, valuable, dear, cheap, behaviour like brave and so on,

Emotive properties : Describing mental states such as moods as angry or kind and so on.

The possibility of constructing sentences which act as adjectival phrases makes such phrases virtually limitless and serve as the basis for a semantic information theory.

Abstract and emotive properties are derived and assigned from highly subjective impressions of aspects of parts of the world and understood by interpretation using the mind/brain in terms of concrete properties which are the only ones reachable by the senses. Such properties can make abstract and emotive properties operational.

**II.** **Question of identity**

Qualitative and quantitative properties tend to be organised into groups which are used for the description of empirical objects as wholes by making statements for their identification thereby converting them into theoretical objects. This kind of intellectual effort led to objects being classified to be seen to belong to groups like species of animals bringing order into a disorderly situation. This effort started with identification of plants and animals and this is how learned disciplines and domains are created.

For example, the properties ‘force’, ‘speed’, ‘momentum’, ‘displacement’, ‘density’ etc. comprise a group of properties for description of objects using statements and creating the discipline or domain of ‘mechanics’. Within a **discipline** statements or principles of more or less generality supplemented by models such as mathematical models or meaningful groups of quantitative properties have been created. Models can be used for exposing the principles to test of experience risking their refutation when applied to objects regarded as single or whole. For example, ‘the cross sectional area of the steel shaft is 0.1 m2’, ‘temperature rise of the planet earth should be less than 0.15 degree Celsius’ or ‘my neighbour is a very friendly person’.

This method has worked well for conventional science of physics for centuries. An example of it is Newton’s 1st law acting as principle and his 2nd law as the mathematical model. The method has been applied to engineering mainly for determination of particular properties of ‘functional elements’ like the elasticity of a spring. It also has been extended to branches of human intellectual endeavour such as artistic and religious thinking in which the use of qualitative properties is predominant and to disciplines like geography and so on.

The method works well as long as it is used for solving analysis or speculative type of problems requiring the use of models for working out final or end conditions for given initial conditions. However, engineering is about ‘problem solving’ i.e. planning or contriving the ways and means for bringing about a desired or expected outcome. The method is applicable to aid the solution of part of problem solving at the single object level but falls far short of application to problem solving activity as a whole. This has caused a number of problems especially in engineering education which, although attempts had been made, has remained unresolved but masked by the extensive use of computers, as far as known.

**III. Question of expectations**

‘Problem solving’ as an ‘activity’ which engineering is, is about resolving ‘problematic issues’ towards satisfaction of a ‘user/consumer’ which is invariably a human being. The 1st step in this direction is the identification of and agreement on a ‘problematic issue’. A problematic issue consists of two parts :

First, an initial state which is seen and described by a statement as unsatisfactory, disliked, uncomfortable and predicated by adjectival phrases which are interpreted as such,

Second, a statement referring to a final or expected state which is seen as the resolution of the initial state and consistent with it.

Engineering or design thinking is about creating the ways and means intended to transform the initial into a final or expected state.

Living things are constantly engaged in problem solving to fight deterioration, to survive and as far as human beings are concerned to achieve a chosen, expected state. Thus the diversity and variety of problem solving activity is immense. A plant turns its leaves towards sunlight, an animal grazes singly or hunts in a group, the lady is polishing her shoe or writing a letter, a clerk is plotting how to get promoted, a person is driving a car. Complex enterprises have been created for constructing a tunnel, manufacturing cars or airplanes, publishing a newspaper, making and erecting a pyramid or a cathedral and so on. All such activities are directed at :

1. Either manufacturing ‘products’ to specifications to exist in static state involving ‘production systems’,

2. Or using ‘products’ which are so manufactured as to become capable of exerting interaction to change the states in a problematic issue, a dynamic state, as part of a ‘consumer system’ so as to satisfy a ‘user/consumer’.

For example, ‘a railway engine’ is the product of a ‘production system’ but it is delivered to be used by a ‘consumer system’ like a railway network for pulling trains. Or a ‘teacher’ is trained at a ‘training college’ but h/she is used in a school to teach history.

We note that realisation of expectations requires a complex, interdisciplinary effort consisting of many objects from different disciplines for the performance of specific ‘functions’ which are interconnected for creating an algorithmic pattern as a whole, both needed for the production of an ‘outcome’. An outcome is described as reaching an appropriate final state of or expectation by a ‘user/consumer’ as part of a ‘problematic issue’. In scenarios with natural, inanimate constituents the outcome is defined as the final, static equilibrium state. In scenarios with natural, animate constituents the outcome is defined as reaching a steady, dynamic state or activity aimed at survival such as feeding. In analysis and design of complex structures or systems or aggregates the ‘structural properties’ are predominant so as to allow ‘energy and information’ to circulate with ‘qualitative and quantitative properties’ entering at a ‘single’ object level leading to a ‘scientific enterprise’.

There is no comprehensive and ‘accepted’ theory of ‘problem solving’. The accepted approach to the analysis and design of ‘problem solving structures’ is combining single disciplines or domains called ‘interdisciplinary work’. This effort is guided by vaguely defined diagrams as practiced in current ‘systems engineering’. In engineering education there is no guidance for students except perhaps the final year project which may need interdisciplinary approach. An alternative approach which is suggested by the current work of the author as the resolution of the ‘problem of interdisciplinarity’, is to seek out those empirical features which are domain independent and then follow the successful method of conventional science as briefly outlined under point II. to create a set of principles supplemented by single linguistic model based on processed natural language of stories or narratives of scenarios. In other words, to admit as the 1st principle of systems that the structural or systemic view of parts of the world is ‘all pervasive’, ‘empirical’ and ‘indivisible’ described predominantly by ‘structural properties’ which are organised into ‘linguistic models’. These models are variations of the single, universal form which is the symbolism that can match the generality of the systemic view. This analytical edifice can be used for investigation of existence of outcomes of scenarios as suggested by the 2nd principle of systems and for supporting design thinking leading to purposive, prototype models which is the 3rd principle of systems.

**Conclusions**

Systems theory as suggested here is created by searching for domain independent, elementary constituents prevailing in the universal domain of which complex structures can be constructed. In this aspect the approach is similar to that of the method of conventional science of physics applicable in a single domain. Living things in particular human beings have been making use of their environment for survival and for the production and use of the huge variety of ‘products’ or artefacts for the resolution of ‘problematic issues’ directly or by employing the equally huge variety of complex structures or organisations without an explicit systems theory. This is only possible if the trait of ability to engage in purposive activity is ‘innate’ in living things. The intense activity is driven by the inventive and creative ability inherent in the mind/brain towards achieving convenience, influence, enhanced performance and so on involving the use of products with specific functions. The question arises what essential factors a systems theory however comprehensive it is claimed to be, can add to this enterprise. A matter for debate.

**Janos Korn writes :**

I came to the United Kingdom as a refugee student in November 1956 and was received with welcome and care by the people of this country. I was given the opportunity for entering higher education and later employment and creating a family for which I express my sincere gratitude. I graduated at Queen Mary College, University of London with an honours degree in mechanical engineering and later obtained the degrees of M Phil and Ph D in the same institution. I spent virtually all my working life in college and university teaching and became a member of the Institutions of Mechanical and Electrical Engineers.

There was a choice of final year subjects between nuclear engineering and control theory or control engineering so I selected the latter thinking that a foreigner would find employment difficult in the former. This choice determined the direction of my teaching and brought me into contact with the large field of control system theories as prevailed at that time. I was also a part time tutor at the Open University in systems behaviour for about 20 years which exposed me to efforts to teach human activity systems or scenarios to adults which was a very stimulating experience.

I soon became dissatisfied with both fields of learning or human intellectual achievement.

Control theory was born out of the problem of how to shoot down enemy aircraft, a moving target, in the 2nd world war. Accordingly, it is based on a problem solving scheme expressed as a mathematical model. It is a purposive, consumer system with an objective which is set by an operator to direct the ‘gun’, the product, to a position to aim at an enemy airplane which is the carrier of the ‘problematic issue’ with the expected or final state of being ‘shot down’. The operator also plays the part of the ‘user/consumer’ observing the expected state. The objective, the position of the gun, is compared with the actual or current state of its realisation at a given time by a feedback loop. The result of comparison is fed into an amplifier which drives a generator which in turn actuates a motor driving a load such as a rotating machinery or an industrial process. An example of this kind of drive is the steering servomechanism driven by the steering wheel of a ship for turning its rudder which is the ‘product’ with the ‘ship’ being the carrier of the ‘problematic issue’. The outcome of this activity is the change of direction of the ship, the final state of the ‘problematic issue’ with the operator of the steering wheel acting the part of the ‘user/consumer’. Identification of constituents with specific functions is a major task.

Control theory is based on transfer function or input – output analysis which

1. Treats both information and energy flows as signals,

2. Uses an amplifier, electronic, biological like a ‘muscle’ or social like a ‘people’s demonstration’ which divides [or unites] the whole scheme into parts in which information and energy circulates,

3. Masks the interdisciplinary nature of energy conversion,

4. Uses mathematics as the symbolism which restricts the application to scenarios with constituents with quantitative properties,

After the 2nd world war the study of this kind of combined human activity and interdisciplinary problem solving scenario developed into a large intellectual activity with its branches like ‘modern control theory’ producing a proliferation of books and published papers. However, when it penetrated into the strongly science based undergraduate engineering courses it created uncertainty because it did not fit. It was alien to mechanical engineering students, students in electronics were more accustomed to the ideas of signals and amplification. A great deal of effort went into trying to accommodate the new ideas by reorganising engineering departments to make crossing of disciplines easier by administering teaching of disciplines and courses separately. A number of committees were set up to enquire into the problems.

All these efforts were of no avail without without an engineering system theory which would have recognised the 'domain independent features' as mentioned in point III. in the technical field, the need for a comprehensive approach to design thinking and a semantic information theory. Trying to resolve this problem I suggested the use of multidisciplinary networks based on the ‘mass – capacitance analogy’ which gave a methodical derivation based on network topology of sets of 1st order differential equations. This method also treated energy conversion in a unified manner including external to internal or dissipation which led to the network and mathematical representation of the 2nd law of thermodynamics. I thought this was a significant achievement recognised by nobody else. The method is described in the publications.

It appears that it was in the 1950’s when von Bertalanffy and associates suggested the idea of ‘systems’ to be universally applicable to parts of the empirical world including human activity scenarios. A huge intellectual development had followed with a large number of books, publications and a variety of views and organisations engaged in furthering various aspects of this idea. However, the idea has the following characteristics which prevail to the present time :

Speculative, with sporadic reference to parts of the world at operational level,

Fragmented into many views, hard/ soft, information systems, administrative

systems, transports systems and so on,

Not in context with the rest of human intellectual endeavor,

Difficult to teach due to lack of symbolism based on accepted branches of knowledge such as mathematics, language and logic,

Has insufficient roots in branches of well established knowledge,

Supplemented by models with ill defined terms without firm theoretical basis,

Usage of diverse and undefined concepts.

However, the practice of the ‘systemic view’ admits discussion of stimulating and divers thoughts mostly related to questions arising from the ‘systemic view’ such as models of organizations, problematic issues in human activities and so on.

In response to this view of current practices in the field of systems thinking I have attempted to develop a different approach to this kind of thinking as outlined in the Summary and described in the publications.

**Selected publications by Janos Korn in ENGINEERING SYSTEMS ANALYSIS AND DESIGN**

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Intertext Books, ed.J Korn, London, 1969

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Bulletin of Mechanical Engineering Education, v9, p343-354, 1970

Alternative derivation of equations of motion

J of the Franklin Institute, v311, n3, p131-150, 1981

Integrated theory of dynamics and control

Systems Science, v12, n1, 1986

Modelling of devices as generalised systems components

J of the Franklin Institute, v324, n3, p479-489, 1987

Systems and design as the basis of engineering knowledge

IEE Proceedings A, v136, n2, March 1989

Fundamental problems in engineering degree courses

European J of Engineering Education, v19, n2, p165-174, July 1994

Theory of spontaneous processes

Structural Engineering Review, v7, n1, p23-34, May 1995

Development of curricula for engineering degrees courses, with E Hatwell

European J of Engineering Education, v21, n1, p27-39, March 1996

Innovation in engineering education

IEE Symposium : Engineering Education, 5 January 2001, London

Network modelling of engineering systems

Troubador Publishing, Leicester, UK, 2012

**Selected publications by Janos Korn in GENERAL SYSTEMS THINKING**

Linguistic modelling-the language of systems science

Systemist, v20, n3, August 1988

Natural language for modelling situations, with F Huss and J D Cumbers

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in Systems prospects : The next ten years of systems research, ed. R Flood, Plenum Publication, 1989

Construction of causal networks through linguistic modelling, with F Huss and J D Cumbers

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Analysis and design of socio-economic systems, with F Huss and J D Cumbers

in Systems thinking in Europe, ed. M C Jackson et al., Plenum Publication, 1991

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International J of AI in engineering, v14, n1, February 1992

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Systemist, v17, n3, August 1995

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J of Engineering Design, v7, n3, September 1996

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Systems for sustainability, ed. F A Stowell et al., Plenum Press, NY, 1997

Design and delivery of information

European J of Information Systems, v10, n1, March 2001

‘Physics’ approach to general systems theory

Kybernetes, v31, n9/10, p1442-51, 2002

Emergence and evolution of complexity

General Systems Bulletin, v23, 2003

Generation of requirements from scenarios

Requirements Quarterly, issue 28, February 2003

Concept and theory of systems

Systemist, v25, n1, June 2003

Elicitation of systems and product from scenarions

Systemist, v26, n1. June 2004

Development of general systems theory

General Systems Bulletin, v35, 2006

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Kybernetes, v36, n5/6, June 2007

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Troubador Publishing, Leicester, UK, 2009

Concept and design of information systems

UKAIS Conference, 24-25 March 2010, Oxford, UK

Statics and dynamics of hierarchy

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Systemist, v32, n2, 2010

From the systemic view to systems science

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International J of Systems and Society, v2, n1, 2015

The purpose of change is problem solving

Troubador Publishing, Leicester, UK, 2016

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