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Systems Approaches to Sustainable Advancement of Developing Countries: Recent Contributions

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Abstract: Advanced information technologies resulting from automation of control and decision expertise and their respective scientific disciplines have essential impacts on the development of national economies within the more and more globalized economy hence a decisive role in ameliorating current socio-economic problems in developing countries. Recent developments have put new emphasis on the IFAC activities dedicated to help improving the technological background of developing countries so as to assists their sustainable but accelerated developments. It is important to keep the focus should be on innovative systems approaches to combined knowledge and technology transfer to developing countries that may remedy their current state of the matters.

1. INTRODUCTION

Recently, in the UNESCO of its Encyclopaedia of Life Support Systems (EOLSS) was presented as: "... a comprehensive, authoritative and integrated body of knowledge of life support systems. It is a forward-looking publication, designed as a global guide to professional practice, education, and heightened social awareness of critical life support issues…". Their definition begins with the sentence "A life support system (LSS) is any natural or human-engineered system that furthers the life of the biosphere in a sustainable fashion". The EOLSS, in some way, has included some 10 subject categories dealing with control, decision and management in systems engineering within its 21 main themes, while only one theme is devoted to Physical Sciences, Engineering and Technology Resources. Furthermore, one of the six goals forming the basis for the design of EOLSS reads "… to elucidate sustainable development, peace, justice, equity and global security…", which clearly supports the IFAC dedication to special activities in support to interests and needs of developing countries (Dimirovski et al, 2006).

A number of system science based studies related to developing countries have as a rule assumed a fixed, stable background (e.g. see Blasi and Ferran, 2002; Brandt and Cernetic, 1998; Coales and Seaman, 1995; Craig and Camisani-Calzolari, 2001; Gibson et al, 1997; Glenn and Hanna, 1995; Hillier and Liberman, 1995; Ilyasov, 2000; Mauro and Franco, 2003; Neck, 2003; Stahre and Martenson, 2004; Stinchombe, 1990; Verndat, 1996; Zaremba et al, 2004;). This implies that many society factors can safely be overlooked or cannot be accounted for by quantifiable methods. However, assumptions that imply a systems thinking within the framework of static system models and environments, which are not sound and much to often contrary to the facts. For instance, many actions to reduce socio-economic imbalances, globally undertaken during the 20th century, in fact postponed problem solutions rather than creating alternative social behaviour likely to reduce underlying problems.

It is within these circumstances that, beginning with the year 2000, IFAC Organization undertook in a new series of professional and scientific events focused on combined knowledge and technology transfer to as well as to innovated systems approaches to investigate the socio-economic phenomenology in developing countries (Craig and Camisani-Calzolari, 2001; Dimirovski, 2001; Dimirovski and Istefanopulos, 2003; Sgurev et al, 2004; Dimirovski, 2007-a). The prevailing current paradigm for studying the effects of technological change is based on assumptions that have lessened in the recent past. Yet, modern mass communications and media have raised personal expectations of by far more people as well as of considerably more nations world-wide than ever before. And one of the main issues is the question whether or not it is possible to distribute the perceived benefits of new technologies as rapidly as the demand for these benefits is increasing. During the last three trienniums, around this delicate puzzle the IFAC dedication in support to professional areas of automation, control and management for socio-economic advancement of developing countries has evolved. This survey is aimed at tracing these activities back, finding out what was achieved and what was missed, and pointing activity focus for the next triennium.

The rest of this survey is written as follows. Section 2 presents some key tasks related to IFAC activities towards the needs of

developing countries. Section 3 discusses some recent IFAC achievements in this regards and some observed trends. In Section 4, some more important points for the immediate future are put forward. Conclusions and references follow thereafter.

2. SOME KEY TASKS RELATED TO IFAC ACTIVITIES TOWARDS DEVELOPING COUNTRIES

In the first place, it should be noted that the issues of automation of decision and control (Beniger, 1986; Molina and Flores, 1999; Blasi and Ferran, 2002; Neck, 2003; Kopacek and Stapleton, 2004; Sgurev et al, 2004; Stahre and Martenson, 2004; Erbe and Llanes-Snatiago, 2007; Dimirovski and Ulengin, 2007) to applications in order to enhance accelerated but sustainable progress in developing countries towards proper and fruitful use of automatic control technologies are somewhat specific. Moreover, it should be noted that this is a process that is not yet entirely understood and still remains somewhat vague (Zadeh, 1984; Dimirovski et al, 2006).

It may well be argued the key problems of concern in relation to developing countries are of a somewhat old nature, known to be inherited from the past century and the actual deficiency of general societal developments in the third-world countries. Yet, it should be also noted that the case of South-East European countries is of deeply different heritage. It appears the only common features are in the inefficient economies and low gross-national product accompanied with high unemployment and wide spread corruption. It is therefore that not only the known ideas of using selected branches of control system technology to address issues of concern and search for solutions, but also these have to be combined with the new paradigms emerging in the contemporary globalization age.

Nonetheless, these known ideas, models and methods in synergy with the new paradigms have to lead to solutions in areas like the following: improving business processes; increasing the economic efficiency of manufacturing production while saving energy and reducing environmental pollution; enhancing progress in developing countries; improving international stability; using systems and control education to assist more efficient society development, etc. It is therefore that technology transfer is a non-separable process of knowledge transfer, and moreover this applies for all levels and advanced technologies, in particular.

One effective framework to turn the combined advance knowledge and technology transfer into socio-economic benefit are the SMEs – small and medium size business and enterprises (Zaremba and co-authors, 2004). Within this SME framework the focus turns to increasing the enterprise efficiency, flexibility, and market responsiveness to adjust to requirements of modern supply chain dynamics and the respective management is closely related to the problems of improving the business process. It should be noted that in the area of decision and control for economic systems and business processes as well as modelling of the respective dynamics, a deep shift towards computational intelligence methods (e.g., see Kosko, 1993; Pete and co-authors, 1998; Wang and Archer, 1998) is under way, along with the newest theoretical advances in methodologies for dealing with perceptions and "computing with words" (Zadeh, 1996, 1999) in computing machines. Moreover, these developments are likely to lead to new uses of qualitative information in decision and control techniques for systems with a distributed information base and partially decentralised control system architectures (Siljak, 1991; Dimirovski, 2007-c). In addition, increasing economic efficiency of production in manufacturing while saving energy (Nikolov and Erbe, 2006), thus reducing environmental pollution too, are tasks of primary concern to decision and control processes for business and economic systems – economic efficiency and financial benefit from advanced knowledge and technologies.

3. RECENT IFAC ACCOMPLISHEMENTS

It has been rightly pointed to the cases of air-traffic and telecommunications infrastructures systems in (Dimirovski et al, 2006) as the ones that do "not distinguish" developing from developed countries because they have to be operated and used within the same margins of safety and security. If at the contrary – all sides may end up in similar troubles or even jeopardised. These again clearly emphasise the subtle essentiality of exploiting to the full the synergy of combined knowledge and technology transfer.

It is this awareness with the IFAC community that have shaped the innovated series of "DECOM-TT" activities with wide co-operation with a number of other IFAC technical committees. Therefore "IFAC-DECOM" objectives have been formulated and aim at promoting the development of control and automation and related systems and control topics in developing countries as well as enhancing knowledge and technology transfer for their sustainable development. The aim is to support economic progress and improve the quality of life in these countries by making a positive impact to enhance productivity, reliability and safety within the areas of industrial processes and infrastructure systems.

Technical contributions to these series may well be inferred from the sessions' titles that comprised the respective technical programs, a brief outline of which is given in the sequel. In addition to the technical contributions, each event of these series has included a set of carefully chosen suitable keynote and plenary lectures, important both for their scientific timeliness and professional impact to enhance sustainable development policies, which served the goal of knowledge and technology transfer to developing countries. The 2000 conference in Pretoria provided the following plenary talks: challenges of creating and maintaining power infrastructure in Zimbabwe – the role of technology transfer; South African transport policy, strategy and implementation; integrated investment strategy for unlocking economic potential in developing countries; automation in operating telecommunications and support systems; and South African water supply industry, a strategic overview of the activity and cost chain. The 2001 workshop in Ohrid contributed as plenary talks: aviation infrastructure in developing countries; neural-network orbit prediction for a geostationary satellite; and control incentives for a leader-follower model in

communication networks and soft-computing potential. The 2003 workshop in Istanbul presented, as plenary talks: active systems – a challenge to contemporary engineering; control applications in physics – from control of chaos to quantum control; composite systems control by combined maths-analytical and FS/NN approach; and an approach to increasing safety operation of air and sea transport. The 2004 workshop in Bansko provided talks about education for automation in developing countries; remote learning of mechatronics; optimising supervision and control for industrial furnaces: predictive control based design; overview of road traffic control strategies; using transport telematics to help developing countries achieve a more sustainable transport infrastructure; macro-system models of flows in communication-computing networks; a DES-supported agent-based control architecture for flexible manufacturing systems.

The technical program of the 2000 conference in Pretoria included the following sessions: energy management; intelligent transportation systems – a reality; bed modular reactors; European experiences in ITS applications; power systems; vehicle identifications technologies; technology transfer in developing countries; water systems; telecommunications – system design and implementation; measurement and control; advanced control applications; education. The 2001 event in Ohrid has contributed the following technical sessions: analytical and computational intelligence techniques for estimation, modelling and identification; maths-analytical techniques for systems control and supervision; maths-analytical and computational intelligence techniques for systems control and supervision; computer control and supervision in telecommunications; industrial CIM automation and robotics; upgrading industrial automation and control infrastructure; industrial control and supervision in power plants and systems; control, management and monitoring in earth's environment; complexity and recognition in system modelling and solving; education, continuing education and re-training.

The 2003 and 2004 workshops in Istanbul and Bansko, respectively, in part expanded on the previous topics with sessions on: analytical control system methodologies; intelligent control system methodologies; manufacturing automation and robotic systems; automation of public buildings and service systems; upgrading industrial automation and control systems; automation and control of electrical power systems; management decisions and decision support systems; and miscellaneous control applications and system designs. It has initiated new subjects in the following sessions: control and management in transportation systems; modelling, simulation and identification; information and communication technologies; advanced controls; intelligent systems; decision making and optimization; control and management of power and water systems; production, automation and robotics; bio and medical system control. The 2007 workshop in Cesme made more emphasis on applied and industrial robotics as well as to academia-industry co-operation (address made Mr Otto Bauer, General Manager of Festo Turkiye) and some novel topics in systems and control theory. Namely, the two delivered invited plenary talks were devoted to "From snakes to Humanitarian assistant robots (by P. Debenest, E. F. Fukishima, and Sh. Hirose, Japan), and to "Nano-robots for micro-factories" (S. Martel, Canada). The conference was run following the sessions entitled: motion, location, sensing and vision; aerospace modelling and control applications; theoretical advances in nonlinear and optimal control; system identification and modelling; fuzzy, neural and fuzzy-neural controls; manipulation, biped and wheeled robots; plant monitoring and process automation; automation and information systems – macro-level problems; automation and information systems – implementation-level problems; special purpose controllers designs; education – general issues; education – teaching and training issues; new results in control of time-delay systems; energy and power control designs; instrument and plant design developments; and complex systems control and modelling problems.

In this series of five events in the recent past, the passing triennium has witnessed the considerable contributions by oriented towards the developing countries within the following IFAC events: Cost-oriented Automation COA 2004 in Gatineau, Canada (Zaremba, Sassiadek and Erbe, 2004); Energy Saving Control in Plants and Building ESC 2006 in Bansko, Bulgaria (Nikolov and Erbe, 2006); and Cost-Oriented Automation COA 2007 in Havana, Cuba (Erbe and Llanes-Santiago, 2007).

At this point, let us recall some of the main topic areas of conferences and papers on system approaches to developing countries: management and development policies; agriculture and food; power; water and pollution control; urban planning, transport and communications; gas, oil and cement industries; methodologies; education and health; human resources; and, finally, international cooperation and development. It should be noted that, by and large, these are as relevant today as they were in the past. Thus it is argued that innovative explorations are needed in order to establish system approaches and means of using automation and control technology to facilitate socio-economic development and enhance technological progress in developing countries. It may be argued that the extent to which "developing countries" objectives will be accomplished also depends on some kind of cooperative forum with other applications oriented technical areas where decision and control are crucial for their sustainable operation such as power plants and systems, transportation systems, advanced agriculture, and small-medium business enterprises. It should be noted, however, innovated and specifically tailored techniques of both phenomenalistic as well as structural modelling are needed in order to respond to the new challenges of applications to social systems (Dimirovski, 2001; Dimirovski and Dinibutun, 2003; Mansour, 2001).

5. SOME POINTS FOR THE NEAR FUTURE

The essentially interdisciplinary character and nature of this area of developing countries within applied systems and control approaches to socio-economical and socio-technical systems has enhanced numerous developments of specific models and techniques. This, in turn, has contributed to systems and control science in terms of appropriate systems approaches applied to human centred and social systems based on exact scientific methods that were borrowed from

control and management decision making. Positive effects from globalization may be reasonably expected only if the negative external effects are correctly internalised into the decisions and activities of all people and into the trade-offs that form the basis of these decisions to manage the transitions of the social system in question. Developments as well as activities in control education apparently have been well defined, considerably matured, and flexibly established for quite some time and continue to progress well. Hence, these developments are likely to continue along the lines of the previous ones in the foreseeable future. In particular, activities have been largely defined and designed so as to always face the timely challenges emerging from advances in theory, applications and technology of control systems, although some issues concerning the theory-practice gap do not seem to have been addressed.

The issues and specific problems related to developing countries, being closely related to global development and international stability, constitute a considerable part of the complex network of systems discussed above and the innovative systems approaches to their study. The background causes and effects of the problems related to developing countries are only partially identifiable and partially controllable. Hence the respective forecasts are presented in more detail. Moreover, these have to be addressed within a multi-disciplinary context encompassing all system science areas relevant to Social Systems, and in co-operation with a number of other technical areas on applications of control. In the long run, education is the most important of all society aspects as pointed out in Mansour (2001 a), hence the issues of developing countries largely coincide with the issues of infrastructure development (Kopacek, 2004 b, c; Mauro and Franco, 2003; Papageorgiou, 2004) and of combined knowledge and technology transfer (Craig and Camisani-Calzolari, 2001; Dinibütün and Dimirovski, 2001; Dimirovski and Dinibütün, 2003).

In contemporary reality the man-made infrastructure systems in almost all fields of human activities, from banking and business through production planning and management to communications (e.g., the internet) and transport, either have become or are becoming essentially trans-national. Thus they now require specification of additional constraints and features in the respective representation models and control strategies, which must be observed in resolving the related control and management problems. Contemporary numerical and linguistic information processing (traditional and soft-computing) technologies, employing both qualitative and quantitative model representations, along with communication technologies have fundamentally changed the environment and platforms on which systems are being designed, implemented, deployed, maintained and operated. There exists sound knowledge on how this can be achieved in a way that is consistent with fundamental ethical principles; only world-wide awareness and the gradual practical implementation of the necessary adjustments are lacking. It is within this framework that the future activities on combined knowledge and technology transfer, contributing considerably to the world-wide awareness of how the globalization process can be turned around for the benefit of all nations as well as individuals, are to be sought. Nonetheless, at this point, it must be emphasised that education and training in all areas of automation and control are of paramount importance

Some concepts and ideas that may remedy critical observations for guiding future advances in control technology toward socially helpful paths within the developing nations may be summarised as presented below.

- *Introducing appropriate actions that can enhance accelerated knowledge and technology transfer hence improve socio-economic stability. stability.* Many actions undertaken during the 20th century to reduce socio-economic imbalances did not alter the general trend of "lagging behind". This pattern feature has to be thoroughly re-examined and substantially modified as appropriate.

- *Introducing proper aid initiatives that revive and stimulate creative engagement of local potentials is crucial.* Various technical aid and financial initiatives to reduce poverty have led to increases in populations being dependent on these initiatives, creating cycles of dependence, which need to be fundamentally altered via effective combined knowledge and technology transfer that activated local mind powers along with the natural resources.

- *Introducing strategic changes to energy, food and water supplies will have a decisive role.* In recent years, population growth world-wide and particularly in developing countries has not kept pace with the manageable availability of energy, food and water so that emerged regional shortages are becoming critical. The causes of these shortages, which create unexpected pressures, have to be explored and remedied via enhancing the infrastructure systems.

- *Affordable automation in conjunction with machine-assisted thinking is a paradigm that has to be made available to developing countries if gap-reducing changes are really to be expected.* Although control engineers have timely and clearly indicated in recent papers how labour-saving aspects of automation have affected labour markets, the process of worker re-training has to keep pace with the need for new skills has net been properly implemented in developing countries. This aspect is bay far more delicate and shall have dramatic impacts in developing countries if not taken proper care in advance learning from the experience in developed countries. Ranks of unemployed or underemployed workers increase rapidly during times of economic contraction, whereas new jobs are created slowly during economic expansions. The term "jobless recovery" does reflect this development and requires novel systems thinking to address in a more perspective way.

It is also worth pointing out some of the new main topics in emerging in business and economic systems that affect small-medium enterprises too. In the first place, the word is about advances in modelling techniques that, among other topics, emphasise: usage of spatial data set and advanced time-series modelling; advanced econometric modelling; agent-based modelling; and financial engineering models. Secondly, the increasing usage of computational intelligence techniques that emphasise: role of intelligent decision support systems; applications of artificial neural networks; methods of genetic algorithms and genetic programming; and computational models based on evolutionary programming. Lastly but not

least the advances in planning and management decision and control emphasise: the use of geographical information systems; advanced forecasting methods; advanced decision-making techniques; and applications of optimization and optimal control methods to national and regional economies. In addition, those need to be studies further relative to the SME implementations in manufacturing production (Kopacek, 2004) and in small-business financial services are gaining in importance, in particular from the point of view of the concept of virtual enterprises (Molina, 1999).

This process of impacts is to continue even more intense in the present day networked world in the globalization age hence the social impact of automation now exhibits a strong phenomenon of world-wide propagation (Blasi and Ferran, 2002; Glenn and Hannan, 2000). In turn, this phenomenon should be brought into the socio-technical system approach of modelling the social impact of automation in an axiomatic way. In this regard the specific approaches of change-management and success-factor need to be revisited in a broader setting, and the necessary improvements in design concepts of human-oriented manufacturing systems and integrated enterprises need to be further elaborated.

6. CONCLUSION

It may well be argued that despite all the efforts in the past by various agencies and institutions under the auspices of the OUN developing countries need more in supporting their accelerated advancements at the age of globalization. The real-life world-wide experience during the last two decades or so has clearly demonstrated that technology cannot be considered as neutral within given society environments.

It can be argued that the IFAC dedication to the series of "DECOM-TT" activities contributes considerably along those lines. Yet it also can be argued that the focus should be on innovated systems approaches to combined knowledge and technology transfer to developing countries, which employing new system and control paradigms and may remedy if not alter the lagging behind of developing countries. For, all contemporary societies are more or less networked and particularly so are the main infrastructure systems of business, energy, food, water supply and transportation. Moreover, some of these are already networked on either continental or global scales, which in turn requires more demanding and sophisticated control, coordination and management methodologies and techniques.

The time has come that the world-wide public becomes daily aware that: (i) control is the true systems technology the utility of which exceeds far beyond the conventional linear feedback control as perceived from most of the existing college textbooks; (ii) this technology is re-shaping the modern societies and it has to be largely used to facilitate speedy advances of developing nations; and (iii) it is the responsibility of the IFAC to orchestrate making this known world-wide at the same time approximately.

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