INNOVATION AND PROBLEM SOLVING WITH AN EMPHASIS ON TRIZ TOOLS

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Summary: While creativity and innovation are popular as buzzwords, they are seldom used in any exact sense. In a decision-theoretic sense, the complexity of a problem is dependent upon the size of the space of decisions in which an optimum is sought. Building an anti-gravity device for example would require billions of experiments, while building a non-standard size bolt requires only interpolation between existing designs, i.e., one experiment. Both the preceding, are in some sense innovations, but the value and difficulty in the former far exceeds the latter.

Design consists in maximizing some performance objective while minimizing performance deviations due to uncertainty under various engineering, economic, legal, social and organizational constraints. It is built around a core of TRIZ ideas developed by Genrikh Altshuller and his associates, but integrates cutting edge discoveries, practices, and tools from a variety of sources—mathematical problem solving, optimization and decision theory, marketing, finance, and management research, and covers the following:

1. Finding the market—a group of people with a job to get done.

2. Defining the job to get done precisely—all the way from design to disposal—so it provides a maximal leap in value compared to what is already available.

3. Idealization: Reducing the size of the search space by precise formulation—
   a. finding the ideal physical effect (e.g., combustion),
   b. the means of using the physical effect (e.g., a gas turbine or internal combustion engine),
   c. and the components with which to accomplish this end (e.g., High bypass turbine/low bypass turbine, 8-cylinder engine, Wankel engine, iron or ceramic or aluminum engine blocks).

4. Developing a variety of solutions to eliminate significant trade-offs in the design problem. This involves reducing the sensitivity of the design optimization problem to both modeling assumptions and operating environments. This effectively decouples the design problem into several lower dimensional problems where both experimentation to identify models and optimization produce far more reliable results.

5. Issues in implementing solutions—designing experiments (including sampling, signal to noise ratio, and richness of measurement), designing projects and teams, strategies to protect IP/build market share.

Some of the course material has been developed through collaboration between an international team of engineers and scientists in industry, and is available on opensourcetriz.com. Besides this material, the course will also contain quantitative tools of analysis, simulation and optimization. Students are expected to choose a specific problem to work on throughout the course. The methods of the course are applied to their problems; several solutions are generated and quantitatively investigated. Previous versions of this course taught by the instructor in industry (Minneapolis MN, Des Plaines IL, Bangalore India) resulted in the generation of lots of IP and the solution of longstanding problems by the teams of engineers and scientists taking the course.
Some History

A systematic study of problem solving or heuristics was perhaps first initiated by mathematicians, as in the works of Jacques Hadamard and later George Polya, with several texts on problem solving available today to train participants in mathematical competitions. There are several notable landmarks in systematizing creativity: Alex Osborne invented brainstorming—essentially random unconstrained search of the solution space; Larry Miles and co-workers invented value engineering at GE during World War II—maximizing bang for the buck within given constraints. The Russian engineer Genrikh Altshuller was the first to empirically analyze engineering creativity in large patent databases, identifying problem types and methods for solving them into various classes. He classified problem types by the engineering trade-offs they contained, and listed the problem-solving methods by which the trade-offs were eliminated. This resulted in the popular TRIZ table of contradictions. Later, Altshuller developed methods to reduce the size of the search space in the problem—tools of *idealization*—formulating ideal expectations of the product, process, or service explicitly. He also simplified the elimination of trade-offs through recognizing the forms by which design problems were reformulated to eliminate trade-offs. Many of Altshuller’s co-workers brought TRIZ to the United States after the fall of the Soviet Union, where it remains popular in various industries. In the 2000s, Larry Ball and co-workers (including myself) refined TRIZ methods by integrating it with Clayton Christensen’s work on Innovation, Miles’s function analysis (for value engineering) and cause-effect chains.

Biography

Kartik B. Ariyur is Visiting Assistant Professor of Mechanical Engineering at Purdue University, and co-founder of the engineering consultancy firm SAMMS LLC currently integrating propulsion, power and thermal management for USAF drones. He has authored over 60 peer reviewed publications, and 17 US patents, and another 15 US patents pending. He has worked on several aspects of autonomous system operation from sensor design and characterization to multi-vehicle mission planning and health monitoring. His projects range from setting integration requirements between health monitoring and adaptive guidance and control for future USAF platforms, to the use of magnetic maps for cell phone geolocation. Prior to joining Purdue, he worked at the Honeywell Labs in Minneapolis where he worked on a range of problems in guidance, navigation, control, health monitoring, system verification and surveillance. His health monitoring algorithms currently run on Honeywell APUs in service in commercial aircraft (around 70% of all commercial aircraft); his front end filtering algorithms developed at Qualcomm reside in all CDMA chips in cell-phones. The thresholds and threshold calculation methods he developed for the LAAS (Local Area Augmentation System) will be used for health monitoring of LAAS receivers in all small airports where the system is installed. He co-authored the text, *Real-time Optimization by Extremum Seeking Control*, published by John Wiley & Sons, 2003. He is currently Associate editor of the International Journal of Adaptive Control and Signal Processing, and member of the Editorial Board of the IEEE Control System Letters. He has served on the program committees of several conferences, including the ACC (American Control Conference), HSCC (Hybrid Systems Computation and Control), IEEE MSC (Multi-Systems Conference), IEEE-SAE connected vehicles conference, and the IEEE Systems Conference, and is a member of the IEEE Controls Systems Society Conference Editorial Board.