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Scope of Application of 'TRIZ' Principles in The Process of Architectural Design Problem Solving

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Abstract

TRIZ is a Russian acronym for "Theory of Inventive Problem Solving" which is a problem-solving methodology developed by Genrich Altshuller and his colleagues in the Soviet Union in the mid-20th century. It deals with the patterns in which creative ideas are generated. TRIZ is a popular application methodology for solving Engineering problems. Architecture is a creative domain and it lies somewhere between Art and Science and a modern architectural creation is dependent to a considerable extent on the contribution of other engineering domains experts. The Researcher has found that there haven't been too many efforts by the architectural community to actively employ these problem-solving techniques propounded by the TRIZ community. Like any other problem-solving processes, Architects are also given a brief or they develop their own based on the initial brief/data/information provided to them by the Client based on which they evolve their own solutions through logical thinking processes after weighing different possibilities, constraints and contradictions. The inventive principles that can be adopted while resolving an Architectural design problem at different phases/levels has been the focus of this Research. Application of TRIZ principles can start at the concept design phase and then gradually move onto other finer applications like individual space design, then interior detailing including furniture/fixture designing and so on. TRIZ has the potential to unshackle the mind of the architects towards more flexible, dynamic and bold decisions. Despite the claim by many architects that architectural design resolution is an intuitive process, the researcher wanted to explore the possibility of the existence of an inherent logic behind design decisions. There are 39 contradictions and 40 inventive principles which creates a matrix that can act as a reference towards providing multiple solution avenues to reach the Ideal End Research (IER).

Keywords: *TRIZ, Theory of Inventive Problem Solving, Architecture, Design Problem Solving*

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It is important for any scientific/technological development to make the researcher(s) access the repository of the previous works. When it comes to problem solving, it has been found that the researcher or the problem solver has used the language which he/she or a very thin section of his fellow researchers understand. The rest are cut out from the benefit of understanding the process involved. Hence, a generalized pattern towards solving a problem understandable by researchers belonging to various fields has the potential to open up a large panorama of opportunities. It can save a huge amount of intellectual man-hours which involves a large number of trials being conducted over a long period of time. This is where the TRIZ system of problem solving comes in.

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Here, in this paper, the focus will be on the 40 inventive principles and not on the 39 contradictions.

The 40 Inventive Principles can be applied towards solving difficult problems related to apparent contradictions. A seemingly impossible problem may be having an undiscovered contradiction – there are two connected things which perhaps are in conflict. By uncovering them and defining the contradiction the relevant 40 Inventive Principles can guide us to resolve the particular contradiction and help the researcher in finding new or fresh ways of getting what he or she wanted.

The researcher has tried to explore the possibilities of applying these 40 problems solving principles in different architectural design domain situations in a tabular format as shown below. In the format, three things have been mentioned: specific TRIZ principle, a brief description of it and the possible zone/area of application in an Architectural design scenario.

Sl. No.	**Name of the TRIZ Principle**	**Brief Description of the Principle**	**Suggested Application in Comprehensive Architectural Design Resolution Which Includes Services and Structures**
1	Segmentation	▪ Divide the object into independent parts. ▪ Make an object easy to disassemble.	▪ Modular furniture ▪ Easy connection/disconnection of service lines
2	Taking Out	▪ Separate an interfering part or property of an object.	▪ Separation of hot part (in the form of outdoor units) of an A.C. or using

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			barking sound of a dog as a burglar alarm.
3	Local Quality	▪ Change the object structure (or external environment) from uniform to non-uniform. ▪ Make each part of an object fulfil a different and useful function. (Example: hammer with nail puller, pencil with eraser etc.)	▪ Using very thin solar panels in the form of transparent sheets on window panes or structural glazing.
4	Asymmetry	▪ Change the object shape from symmetrical to asymmetrical. ▪ If an object is asymmetrical, increase the degree of asymmetry.	▪ Guggenheim Museum in Bilbao, Spain, designed by Frank Gehry, is an apt example of asymmetrical design that brings us some vibrancy and creates an unusual form which is spectacularly different from the existing urban setting.

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5	Consolidation	▪ Bring closer or merge identical or similar objects.	▪ Consolidation of services ducts in the common lobby area in a typical apartment building tower.
6	Universality	▪ Make a part or object perform multiple functions, eliminating the needs for other parts (common example: handle of a toothbrush containing toothpaste, mulching lawnmower)	▪ Painting a wall with such a paint which can turn it into a projection plane or may also have acoustical and intumescence properties.
7	Nested Doll	▪ Placing one object inside the other and so on ▪ Make one part pass into the cavity in the other. (Example: extending radio antenna, zoom lens)	▪ Using retractable furniture or foldable furniture, stackable chairs etc. ▪ Foldable staircase fixed to the wall.
8	Anti-weight	▪ To compensate for the weight of an object, merge it with other objects that provide lift (E.g.: using helium balloons to support advertising signs)	▪ Using counterweight for elevator systems – energy saving. ▪ Floating structures

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		▪ To compensate for the weight of an object, make it interact with the environment (E.g.: using buoyancy or aerodynamic or other forces)	
9	Preliminary Anti-action	▪ If it will be necessary to do both an action with both useful and harmful effects, this action should be replaced with anti-action to control harmful effects (E.g.: prestressing/post-tensioning)	▪ Using sustainable or renewable energy or recycled materials are examples of this TRIZ principle.
10	Preliminary Action	▪ Perform before it is needed the required change of an object (either fully or partially) E.g.: sterilizing surgical instruments in a sealed tray, pre-pasted wall paper etc.	▪ Pre-engineered buildings, pre-fabricated structures or ready-mix-concrete are best examples of this principle.
11	Beforehand cushioning	▪ Prepare emergency means beforehand to compensate for the relatively low reliability of an object (E.g.: Back-up parachute)	▪ Any kind of back-up or auxiliary systems can be examples of this principle. Diesel generator-based power

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			backup systems or any type of safety factors.
12	Equipotentiality	▪ Change the condition of the work in such a way that it will not require lifting or lowering an object. E.g.: Equipotentiality means finding ways to avoid this heavy work. For example, a chest of drawers: to get to things at the bottom one doesn't need to take out all of the things on top (and then put them back again).	▪ Ramps used for wheelchair bound people is a common example.
13	The other way round	▪ Invert the action used to solve the problem (E.g.: instead of cooling, object is heated) ▪ Make movable parts fixed and fixed parts movable. ▪ Turn the object or the process upside down.	▪ Open plan offices. ▪ Windows which are openable – tilting and turning facilities.
14	Spheroidality, curvature	▪ Instead of using rectilinear part, using curvilinear parts	▪ Using arches or domes for strength or distribution of

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		▪ Go for rotational than linear movement – using centrifugal forces.(spinning clothes to wringing clothes)	load over a large column-free span. ▪ Tensegrity structures
15	Dynamics	▪ Allowing the characteristics of an object, external environment or a process to change to certain optimum positions/values. ▪ (E.g.: adjustable seats, supports etc.)	▪ Using polymers with shape memories. ▪ Using photochromatic glasses. ▪ Retractable roofing systems
16	Partial or Excessive Actions	If 100% percent of any action is hard to achieve then settling for a little more or a little less. ▪ (E.g.: filling petrol in a car – it is not completely full – a little less than the maximum capacity is considered the best achievable volume).	▪ Little less example; Optimization of design – say for HVAC systems – satisfaction of 80% users. ▪ Little more example: overdesigning of beams or applying more plaster and then removing the excess part.

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17	Another Dimension	▪ To move an object in two or three dimensional space. .	▪ Use of triangulation to bring in structural stability. ▪ Slotted iron systems for creating racks.
18	Mechanical Vibration	▪ Cause an object to oscillate or vibrate. ▪ Increasing its frequency of vibration, using an object's resonance frequency or using piezoelectric vibrators ▪ Using a combination of ultrasonic and electromagnetic field oscillations.	▪ Use of needle or plate vibrator for removal of porosity of concrete. ▪ Crack detection system using ultrasound.
19	Periodic Action	▪ Instead of continuous actions, use periodic or pulsating action (E.g., hitting something with a hammer) ▪ If an action is already periodic change the periodicity – periodic magnitude or frequency.	▪ Architectural analogy could be use of sensor based design adjustments related to daylight or occupancy.

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		▪ Use pauses between impulses to perform a different action. .	
20	Continuity of useful action	▪ Carry on work continuously; make all parts of an object work at full load – all the time. (E.g., flywheel or hydraulic system stores energy when a vehicle stops so that the motor can keep running at optimum power); ▪ Eliminate all idle or intermittent actions or work (E. g. printing during the return of a printer cartridge);	▪ Use of self-cleaning systems like self-cleaning filters. ▪ Converting circulation areas or lobbies into usable private spaces when needed.
21	Skipping	▪ Conduct a process or certain stages (e.g., destructible, harmful or hazardous operations) at a high speed. (E.g., cutting at a high speed to reduce heat generation scope).	▪ Laying of roofing materials at a fast pace. Like an inflatable roof stage structure so that an enclosed space can be quickly created.
22	Blessing in Disguise or turn	▪ Use harmful factors to achieve a positive effect (e.g., use waste heat to	▪ Using waste heat to generate electricity.

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	lemons into lemonade	generate electric power; recycle waste) ▪ Eliminate the primary harmful option by adding it to another harmful action to resolve the problem). ▪ Amplify a harmful action to such a degree that is no longer harmful.	▪ Completely glazed houses like solariums to maximize heat gain during daytime.
23	Feedback	▪ Introduce feedback to improve a process or action (E.g., automatic volume control in an audio system) ▪ If feedback is already used change its magnitude or influence (change sensitivity of a thermostat so that it can work more efficiently while cooling)	▪ Automatic flushing for cisterns in toilets. ▪ Involving manufacturers in the design, tendering and execution stages.
24	Intermediary	▪ Use an intermediary carrier article or intermediary process. ▪ Merge one object into another (which can be easily removed. e.g., potholder for carrying hot dishes to the table).	▪ The intermediate door made of wire mesh for safety and security. ▪ Velcrow based window screen for sound

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			insulation or protecting from insects.
25	Self-service	▪ Make an object serve itself by performing auxiliary helpful functions. (E.g. halogen lamps regenerate the filament during usage by redeposition of evaporated materials) .	▪ Earth berm houses. ▪ Self-levelling concrete. ▪ Nano-technology based self-cleaning cladding surfaces. ▪ Cogeneration
26	Copying	▪ Instead of using an unavailable, fragile and expensive object use simpler and inexpensive copies. (e.g. conducting virtual seminars instead of physical ones) ▪ Replace an object or process using optical copies. ▪ If visible optical copies are already used, move to infrared or UV images. (E.g. make images in infrared to detect heat sources like detecting diseases in crops)	▪ Artificial turf. ▪ Using satellite imageries instead of physical surveys. ▪ Using UV rays as a non-destructive crack detection method.

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27	Cheap, short-living objects	▪ Replace an expensive object with multiple inexpensive objects. (E.g. using paper plates instead of steel plates to avoid the time, money and energy of washing and storing).	▪ Artificial turf. ▪ Movable toilets used in construction sites for workers or for temporary shelters.
28	Mechanics Substitution	▪ Replace mechanical means by sensory (optical, acoustical, taste or smell)	▪ Electrified switchable or privacy glass panes. ▪ Electrical or acoustical fence.
29	Pneumatic and hydraulics	▪ use gas or liquid parts of an object instead of solid parts (e.g., inflatable, filled with liquids, air cushions hydrostatic, hydro reactive etc.)	▪ Hydraulic lifts are apt examples.
30	Flexible shells and thin films	▪ Avoiding seemingly rigid enclosures.	▪ Using flexible shells and thin films than 3-dimensional structures.
31	Porous Materials	▪ Make an object porous or add porous elements (inserts, coatings etc.)	▪ Cavity wall construction ▪ Using AAC bricks

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32	Colour changes	▪ Changing the colour of an object or its external environment. [using safe lights in a photographic dark room]	▪ Using dynamic lighting pattern in a room for providing varying user experience.
33	Homogeneity	▪ Making objects interacting with given object of the same material (or material with identical properties) [	▪ Making the container with the same material as the object contained to avoid chemical reactions.
34	Discarding and recovering	▪ Making portions of the object go away after the functions have been fulfilled (dissolving or evaporating) ▪ Conversely, restoring consumable parts of an object during operation.	▪ Using sacrificial formwork for concreting ▪ Reusing formwork for concreting like Mivan construction.
35	Parameter changes	▪ Changing the physical states of an object from e.g. gas, liquid or solid/ changing concentration or consistency/changing the degree of flexibility/changing the temperature.	▪ Using liquified silicon sealants for windows or door insulation system. ▪ Using liquid plastic as sheet covering or paints for roof insulation.

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36	Phase transitions	▪ Using phenomena occurring during phase transitions (increase of volume or loss/absorption of heat) [expansion of water while turning into ice]	▪ Using ice as a base material for gently lowering heavy structures.
37	Thermal Expansion	▪ Using thermal expansion or contraction of materials [thermostatic effect happens using multiple metals]	▪ Shape-memory polymer rivet fasteners as advanced screwing techniques.
38	Strong oxidants	▪ Replacing common air with oxygen-enriched air.	▪ Using ozone-based air for releasing oxygen in air-pollution situations.
39	Inert atmosphere	▪ Replacing normal environment with inert one. [metal filament in an argon environment]	▪ Using argon filled double or triple glazed window systems. ▪ Using inert gas environment for Fire safety.

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40	Composite Materials	▪ Changing from uniform to composite (multiple) materials	▪ Use of Fiberglass for lightweight and flexible structures/objects ▪ Fibre-reinforced concrete.

The examples given above are solutions which have been in use for a long time in the Architectural, construction/interior design industry. However, it is easy to see that applicability of TRIZ based solutions have infinite possibilities depending on how horizons are pushed by bringing in synergy between cutting edge technologies being developed in various fields and their applicability in this specific domain related to Architecture (and may be Urban Design and other related areas). Involving more or more of these principles can change the traditional way of resolving architectural design problems.

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