AC 2012-3797: EVALUATING IDEATION USING THE PUBLICATIONS POPULAR SCIENCE, POPULAR MECHANICS, AND MAKE IN COORDINATION WITH A NEW PATENT SEARCH TOOL AND THE 6-3-5 METHOD

Dr. Daniel D. Jensen, U.S. Air Force Academy

Dan Jensen is a professor of engineering mechanics at the U.S. Air Force Academy, where he has been since 1997. He received his B.S. (mechanical engineering), M.S. (applied mechanics), and Ph.D. (aerospace engineering science) from the University of Colorado, Boulder. He has worked for Texas Instruments, Lockheed Martin, NASA, University of the Pacific, Lawrence Berkeley National Lab, and MSC Software Corp. His research includes design of Micro Air Vehicles, development of innovative design methodologies and enhancement of engineering education. Jensen has authored approximately 100 papers and has been awarded more than $2.5 million of research grants.

Dr. John J. Wood, U.S. Air Force Academy

John J. Wood is currently an Associate Professor of engineering mechanics at the U.S. Air Force Academy. Wood completed his Ph.D. in mechanical engineering at Colorado State University in the design and empirical analysis of compliant systems. He received his M.S. in mechanical engineering at Wright State University and his B.S. in aeronautical engineering from Embry-Riddle Aeronautical University in 1984. Wood joined the faculty at the U.S. Air Force Academy in 1994 while serving on active duty in the U.S. Air Force. After completing his Ph.D. in 2002, he returned to the Air Force Academy where he has been on the faculty ever since. The current focus of Wood's research is the continued development of empirical testing methods using similitude-based approaches. This approach provides significant potential for increasing the efficiency of the design process through a reduction in required full-scale testing and an expansion of the projected performance profiles using empirically-based prediction techniques. Wood's research also includes the development of robotic ground and air vehicle systems using innovative conceptual design techniques for current technology implementations, as well as futuristic projections, applied in the framework of a senior capstone design course.

Mr. Philip Knodel, U.S. Air Force Academy

Philip Knodel is currently a senior at the U.S. Air Force Academy and will commission as a Second Lieutenant in the Air Force this May. At the academy, Knodel has studied to earn a B.S. in mechanical engineering for the past four years. As an officer, Knodel has been selected to serve as a pilot. Apart from his job and studies, Knodel is also an avid snowboarder and has a passion for sailing, having traveled and sailed in more than 20 countries around the world.

Prof. Kristin L. Wood, University of Texas, Austin

Kristin L. Wood is currently a professor, Head of Pillar, and Co-director of the International Design Center (IDC) at Singapore University of Technology and Design (SUTD). Wood completed his M.S. and Ph.D. degrees in mechanical engineering (Division of Engineering and Applied Science) at the California Institute of Technology, where he was an AT&T Bell Laboratories Ph.D. Scholar. Wood joined the faculty at the University of Texas in Sept. 1989 and established a computational and experimental laboratory for research in engineering design and manufacturing. He was a National Science Foundation Young Investigator, the Cullen Trust for Higher Education Endowed Professor in Engineering, and University Distinguished Teaching Professor at the University of Texas, Austin.

Dr. Richard H. Crawford, University of Texas, Austin

Richard H. Crawford is a professor of mechanical engineering at the University of Texas, Austin, and is the Temple Foundation Endowed Faculty Fellow No. 3. He received his B.S.M.E. from Louisiana State University in 1982 and his M.S.M.E. in 1985 and Ph.D. in 1989, both from Purdue University. He joined the faculty of UT in Jan. 1990 and teaches mechanical engineering design and geometry modeling for design. Crawford's research interests span topics in computer-aided mechanical design and design theory and methodology, including research in computer representations to support conceptual design, design for manufacture and assembly, and design retrieval; developing computational representations

and tools to support exploration of very complex engineering design spaces; research in solid freeform fabrication, including geometric processing, control, design tools, manufacturing applications; and design and development of energy harvesting systems. Crawford is co-founder of the DTEACh program, a Design Technology program for K-12, and is active on the faculty of the UTeachEngineering program that seeks to educate teachers of high school engineering.

Mr. Robert Vincent, U. S. Air Force Academy

Department of Engineering Mechanics

Evaluating Ideation using the Publications *Popular Science, Popular Mechanics* and *Make* in Coordination with a New Patent Search Tool and the 6-3-5 Method

Abstract
The ideation or concept generation stage in the design process is ripe with possibility for infusion of creativity that can lead to the development of innovative products and systems. Along with the desired creativity or novelty, concepts must also be feasible in order to have promise as fielded products. This combination of desired novelty and required feasibility can be difficult to attain. Various ideation techniques have been developed which aid the designer in their quest for an innovative new product or system. In the current work, we evaluate four ideation techniques: use of the publications *Popular Science* and *Popular Mechanics*, use of the publication *Make*, use of a new patent search tool and use of the 6-3-5 "brain writing – rotational drawing" technique. The four techniques are described in detail with particular emphasis placed on a description of the patent search tool as this ideation technique, based on recently developed software, has not been previously disseminated. The techniques are then assessed to determine their utility in terms of quantity of ideas generated, novelty of the ideas and feasibility of the ideas. This assessment was done in the context of a capstone design team at the US Air Force Academy working on a robotics oriented project. Specifically, the design team is developing small robots with the ability to maneuver through rough terrain in caves or tunnels for surveillance purposes. Representative assessment results include the fact that the design team was able to produce over 20 new concepts using the new patent search tool; validating that this new technique shows great promise. Also, the feasibility of the concepts created using the *Make* publication was significantly higher (p-value of 0.06) than the concepts from the *Popular Science* and *Popular Mechanics* publications while the novelty ratings between these two showed no statistically significant difference. Overall the team generated over 130 concepts with the largest contributors to this quantity coming from the *Make* publication and the 6-3-5 technique. The paper concludes by noting the unique characteristics and resulting contributions from each of the four ideation techniques along with suggestions regarding which technique(s) might be most beneficial depending on the nature of a specific design challenge.

1. Overview

It is difficult to underestimate the importance of innovation and creativity in design particularly in the presence of an increasingly global economy. The activity of concept generation (CG), or more generally ideation, presents tremendous and unique opportunities for enhancing creativity and the resulting innovation. In this light, we are investigating additions to our suite of CG techniques. Based on influential ideation techniques, as well as original research we have conducted in this area, we have developed a suite of CG techniques to assist in the design process [1, 2]. The techniques included mind-mapping, a modified 6-3-5 or C-Sketch technique

[3], functional decomposition combined with morphological analysis [4], Theory of Inventive Problem Solving (TIPS/TRIZ) [3], a method to produce products with the ability to transform or reconfigure [5], a search for cross-domain or far-field analogies [2], implementation of creativity principles from historical innovators [1], and a design by analogy technique using a WordNet-based search procedure [6]. The fundamental premise of this suite is to enable designers to develop innovative concepts well beyond those they would have created through *ad hoc* or singular, intuitive CG techniques. Through a suite of techniques, fixation, group think, and other cognitive barriers may be mitigated, we surmise, leading to an enhanced ability to ideate.

In this present work, we are investigating the effectiveness and interrelationships between four techniques. Two of these techniques have been evaluated previously: 1) Use of the technical trade publications *Popular Science* and *Popular Mechanics* (*PS-PM*) [7], and 2) the 6-3-5 "brain writing – rotational drawing" technique [3]. The other two techniques have not been previously investigated: 3) use of the publication *Make*, and 4) a recently developed patent search technique [8]. The focus of this current research is to measure the effectiveness of these four techniques when used together and to understand in what contexts each technique might have special usefulness.

2. Context

Numerous versions of the "design process" have been proposed [3, 9-11]. Two examples are captured in Figures 1 and 2. Figure 1 shows the process as depicted by Ullman [9] and Figure 2 provides a similar description from Ulrich and Eppinger [10]. In both these cases, and in the majority of other portrayals of the design process, one of the key steps in the overall process is identified as "concept generation." As shown in Fig. 3 from Otto & Wood [3], the CG step itself can be separated into a set of sub-processes. Note the dual paths depicted in the figure, which divide the process into two categories, basic and advanced. Similarly, Shah [12] uses two categories referred to as intuitive and directed as shown in Figure 4. The upper path in the figure corresponds to the intuitive type CG methods and the lower path to directed or discursive-bias methods. The goal of the intuitive methods is to create an environment that enhances creativity for the designer allowing for maximum opportunity to produce novel, and ultimately innovative, solutions. Classic examples in the intuitive category include brainstorming, extended brainstorming with mind-mapping and morphological analysis. The goal of the directed methods is to use knowledge or process steps outside the typical background of the designer to develop concepts. Technical information combined with fundamental physical laws and design principles play a key role in this directed method set of CG techniques.

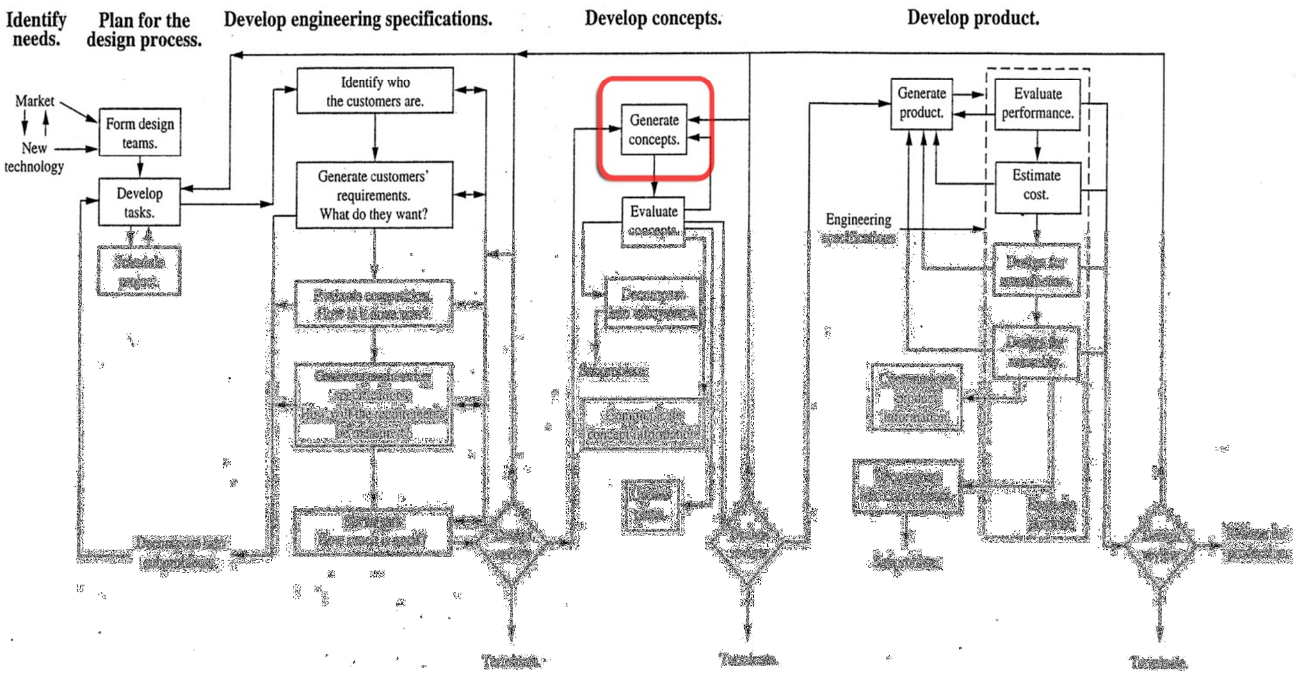


Figure 1. Ullman's depiction of a design process [5].

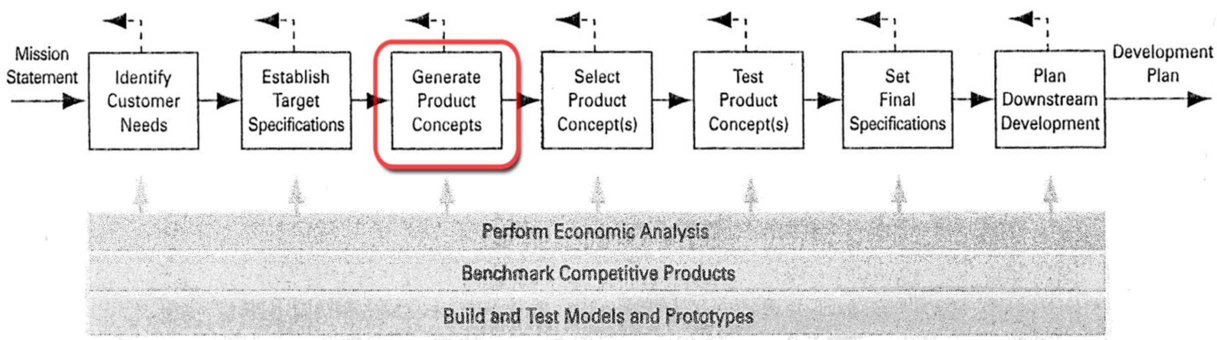


Figure 2. Ulrich & Eppinger's depiction of a design process [6].

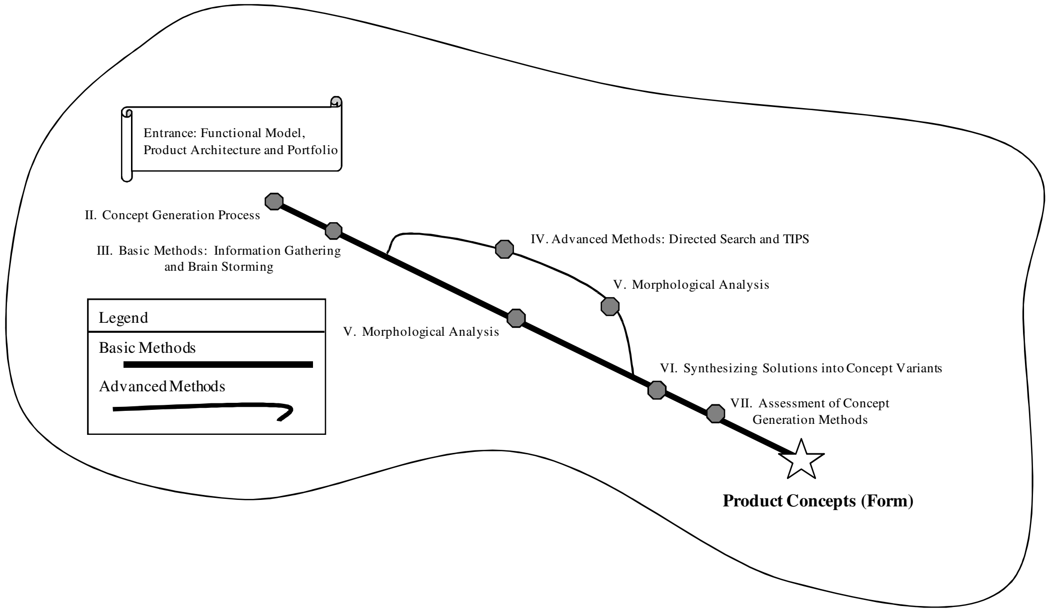


Figure 3. Otto & Wood's depiction of concept generation [7].

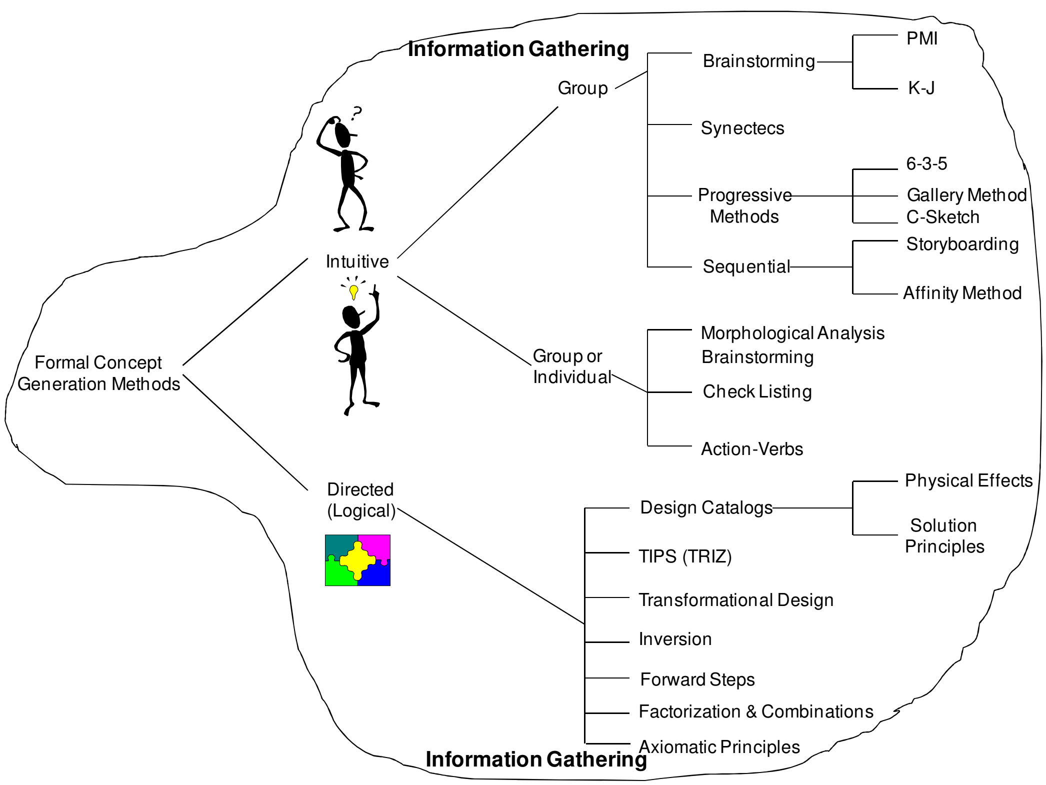


Figure 4. Types and names of concept generation methods (adapted from Shah [9]).

The current study was accomplished in the context of a senior undergraduate capstone design project. The project spans two semesters and is normally divided so that the first semester involves problem description, customer needs analysis, requirements development, CG and some initial feasibility/risk analysis leading to a Pugh-based down select of concepts. The second semester focuses primarily on manufacturing and iteratively testing/tweaking in an effort to satisfy all the design requirements. The specific team that used the four CG techniques is jointly sponsored by the Department of Homeland Security and the Department of Defense. Eight students and a faculty advisor make up the team. The team is working to design, build and test robotics systems that have the ability to be lowered from the ground surface through an 8-inch diameter bore hole, to a depth of up to 100-feet into a tunnel or cave with an approximate cross section of 4 feet by 4 feet. The robot is tasked with navigating over difficult terrain, including the ability to overcome a 24-inch vertical step to perform intelligence, surveillance and reconnaissance (ISR) missions. Applications for this technology include rescue missions in mines, homeland security missions along the border or military operational missions where tunnels are being used to transport or store contraband. These robots must be able to operate in tight spaces and navigate through water and mud and over ledges, large rocks and even climb stairs and ladders. The small size constraints (based on the 8 inch insertion/extraction bore hole) and the aggressive navigation requirements for these systems pose extremely significant design challenges.

This has been a multi-year project with each year's final designs originating from varying components from the CG suite mentioned above. During the 2009-2010 capstone design course, the students designed a dual-powered Ducted Fan Climber robot system using a two-wheeled configuration to better facilitate the insertion and extraction requirement. The robot used a differential steering scheme with a trailing stabilization device and is shown in Figure 5 below.

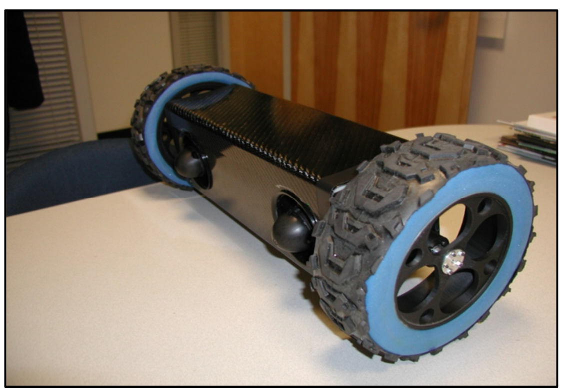


Figure 5. Ducted Fan Climber counter-tunnel robotic system [13].

The counter-tunnel robotic system contained two independent propulsion systems. The primary drive system was designed to allow the robot to navigate on flat or relatively simple terrain. This drive system was comprised of simple electric geared motors controlled through an electronic speed control remote controlled radio system. The secondary propulsion system was designed specifically to enable the robot to navigate the 24 inch specified obstacle. The robot concept used a ducted fan propulsion system to accomplish this task and other climbing maneuvers. The climbing mechanism is comprised of dual fans and a pair of stabilizer wheels to provide the required thrust angle for climbing.

The main body of the Ducted Fan Climber robot was a rectangular tubular chassis with a removable top to allow access to the robot components. The chassis end plates were designed to maintain the structural integrity of the chassis while also providing a mounting structure for the electric motors. The robot used the dual fan motors to aid in climbing over obstacles that are too steep or too difficult to negotiate with the primary drive system. The purpose of the ducted fans was not to lift the robot in the vertical direction but rather, to increase the normal force, and thereby the frictional force, between the wheels and the surface to be climbed. This allowed the robot to use the primary drive system to simply drive up the surface while the secondary ducted fan propulsion system provided the frictional force required to climb.

During the 2010-2011 capstone design course, the students designed a robot system that deployed an electro-adhesion pad that would adhere to any tunnel surface. This pad would provide a fixed “hold” that could then be used to lift the robot over obstacles found in a typical tunnel environment. The electro-adhesion prototype robot is shown in Figure 6 below.

Figure 6. Electro-Adhesion counter-tunnel robotic prototype [14].

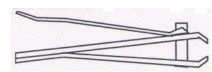
Electro-adhesion is the process of electrically charging a metalized fabric (commonly used in space blankets) to generate enough charge to stick to a surface analogous to rubbing a balloon on your head to get it to stick to a wall. This is accomplished using a relatively low voltage supply combined with a DC-DC converter to increase the charge voltage. The result of the conversion is a pad charged to between 5000 Volts and 10,000 Volts at extremely low amperage.

3. Description of the Four CG Techniques

3.1 Morphological Analysis Combined with 6-3-5 Directed Brainstorming

Morphological Analysis often originates with functional decomposition, a method that helps designers describe *what* a product will be required to do (functions), *not* *how* it will accomplish these tasks (embodiment). There are a number of different ways to accomplish this functional decomposition with common methods including function trees and function structures [4]. Functional decomposition combines with morphological analysis to provide a method for organizing potential embodiments for each function [3]. Figure 7 shows a very simple morphological analysis matrix for a set of finger nail clippers. The design problem is first broken down into its functions. The functions of the device are then listed in the first column. Solutions (embodiments) that were generated during the CG process are then organized by their function in the remaining columns.

Morph Matrix: Finger Nail Clipper



Function	Solution 1	Solution 2	Solution 3
Apply finger force	shaped top, bent bottom	shaped top and bottom	
Convert to large force	pivot	linkage	
Move file into place	pivot out file	file on arm	slide arm out
Stop motion	teeth hit	mechanical stop	
Release force	spring of bent body		

Figure 7. Morph Matrix containing functional solutions for a set of finger nail clippers [3].

In the classic method of "brainstorming," a small group of people openly discuss possible new solutions to an existing problem or conceptual solutions for new design problems. While this method may be effective in some forums, it has been shown in some design situations to lack the synergistic effect that is desired. Specifically, research shows that in some situations the group will not produce more quantity or quality of solutions in this "brainstorming" environment then a group of individuals working alone [15, 16]. This finding has led many in the design community to adopt a modified brainstorming technique called 6-3-5, which is described graphically in Figure 8. In this technique, a small design team (approximately 6 members) each takes the initial 5-15 minutes of the exercise to develop a small number of concepts intended to solve a design problem. These ideas are captured through a combination of sketches and words. Optimally, large sheets of paper and different colored markers are provided for each participant. After this initial 5-15 minutes, participants pass their paper to the adjacent team member. An additional 5-10 minutes are now provided for the members to add to/comment on the ideas of their colleague, or create an entirely new idea as inspired by the sketches passed to them. This rotational process continues until each member has taken the opportunity to add to the concepts from all other members. No verbal communication is allowed during this entire process until all team members obtain their original concept sheet.

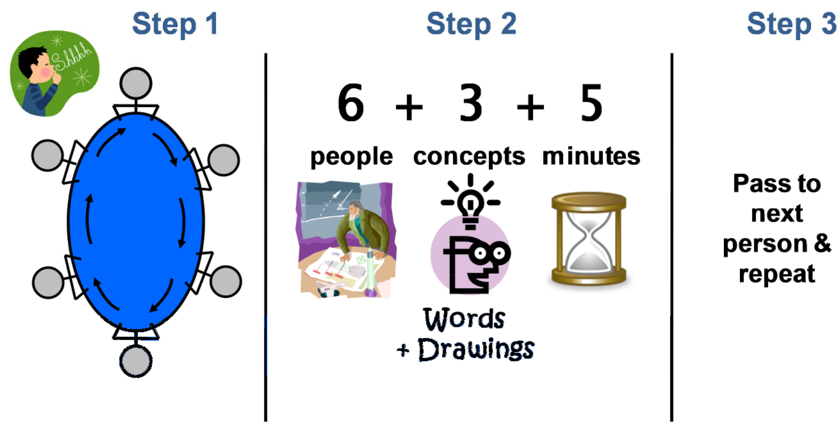


Figure 8. 6-3-5 concept generation process [3].

In our particular case, we have combined the 6-3-5 technique with Morphological Analysis and implemented the method following a function structure type functional decomposition of the problem. The ideas developed from 6-3-5 were arranged in a morphological matrix based on how they met certain functions. Figure 9 shows a sample result from the first and second round of a 6-3-5 session. In the first time period, one of the team members drew three different solutions to the problem of a device to shell peanuts. During the second time period, a second team member combined and added detail to the original set of ideas.

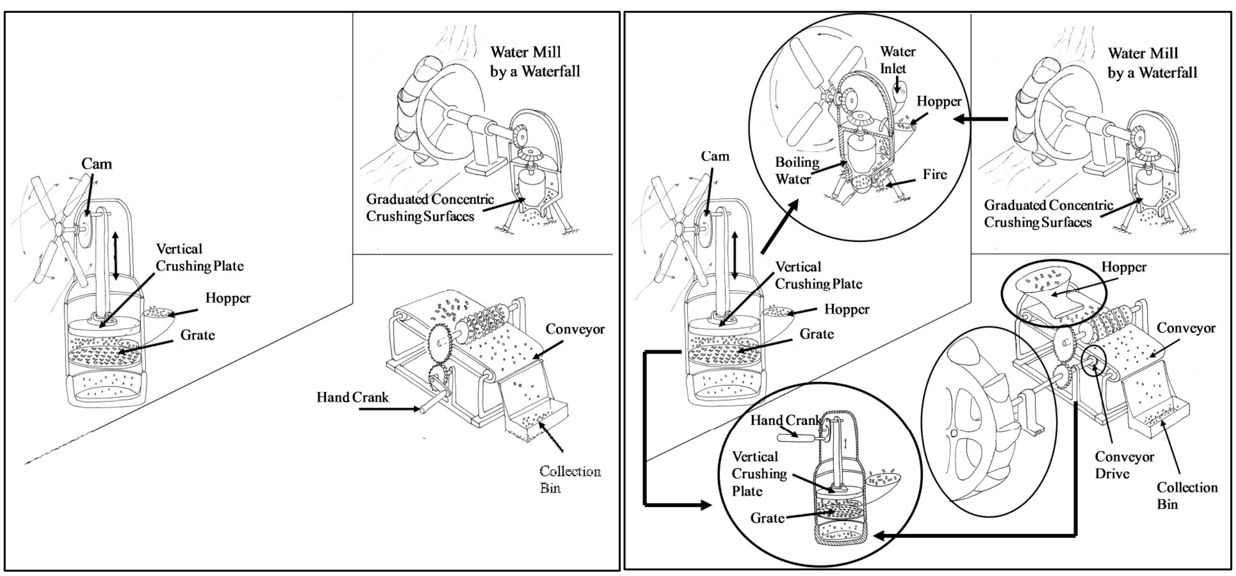


Figure 9. Example results from a first and second round of 6-3-5.

3.2 *Popular Science/Popular Mechanics* Based Concept Generation

Our development and implementation of the *Popular Mechanics/Popular Science* (*PM/PS*) (see Fig. 10) technique was based on two assumptions:

1. Students are not familiar with emerging technologies that might be directly applicable to their design.
2. Exposing the students to emerging, innovative technologies will spawn creativity in the concept generation phase of their design.

Figure 10. Examples of publications *Popular Mechanics & Popular Science*.

This new concept generation technique was inspired, in part, by the work of Saunders, Seepersad and Holtta-Otto [17], which used *Popular Science*, *Popular Mechanics* and other similar periodicals to uncover engineering characteristics inherent in award-winning innovative designs. Team members were asked to review copies of *PS/PM* periodicals and search for technology which was relevant to their project. Not only were they encouraged to find technology that might be directly applicable to their design (for example a new type of robotic locomotion), but also to look for emerging technology they might use in ways that the original inventor did not anticipate.

3.3 *Make* Based Concept Generation

Based on prior success of utilizing *PS/PM* in our design curriculum and the lingering difficulty that students have implementing innovative solutions, an additional publication was added to the mix – *Make* magazine. This publication has some of the technological innovation of *PS/PM* but takes an instructable.com approach to explaining how the technology could actually be implemented. This level of detail helped open the students' minds to possibilities they thought too complex or difficult. Additionally the detail served to allow them better cross-application of ideas since they had a deeper understanding of the problems faced when developing the technology and the work-arounds that the inventor created to arrive at the published solution. Team members read through multiple issues of *Make* and copied useful and/or interesting ideas that could be utilized as building blocks for their final concept.

Note that both the PS/PM and the Make based techniques may be relevant for use in the context of reference designs. Students (possibly in a freshman design class) might be asked to review the publications and select a few of their favorite articles. They might then be asked to apply the technology from those articles to some set of common household (and therefore familiar) technology issues.

Figure 11. Examples of publication *MAKE.*

3.4 Patent Search Technique for Concept Generation

Since 1976 full text patents have been available electronically. There are currently over 4 million full text patents accessible online. Several fundamental properties of patents create an ideal source for design knowledge:

- By definition, a patented device must be *useful* and *novel*
- Patents are meticulously categorized into an organized classification structure
- Patent documents follow a well-defined structure
- Established information retrieval techniques can be applied

Although the potential advantages of using the patent database as a part of a CG process are evident, developing a method to narrow the field of potential patents to a manageable number is critical if the patent database is to be a useful CG tool. As part of a recent Ph.D. thesis at the University of Texas [8], Murphy developed a software tool that uses the functional description of the design problem to search a patent database in order to provide analogies with the hope of inspiring designers during the CG process. The software is available by contacting the author. As can be seen in Figure 12, the user selects primary, and then secondary (Fig. 13) functions. The process progresses until a set of patents has been identified that have functional similarity to the designer's problem (Fig. 14). For a more detailed process description, please see appendix A which contains Murphy's "Analogy Patent Search Engine User Guide".

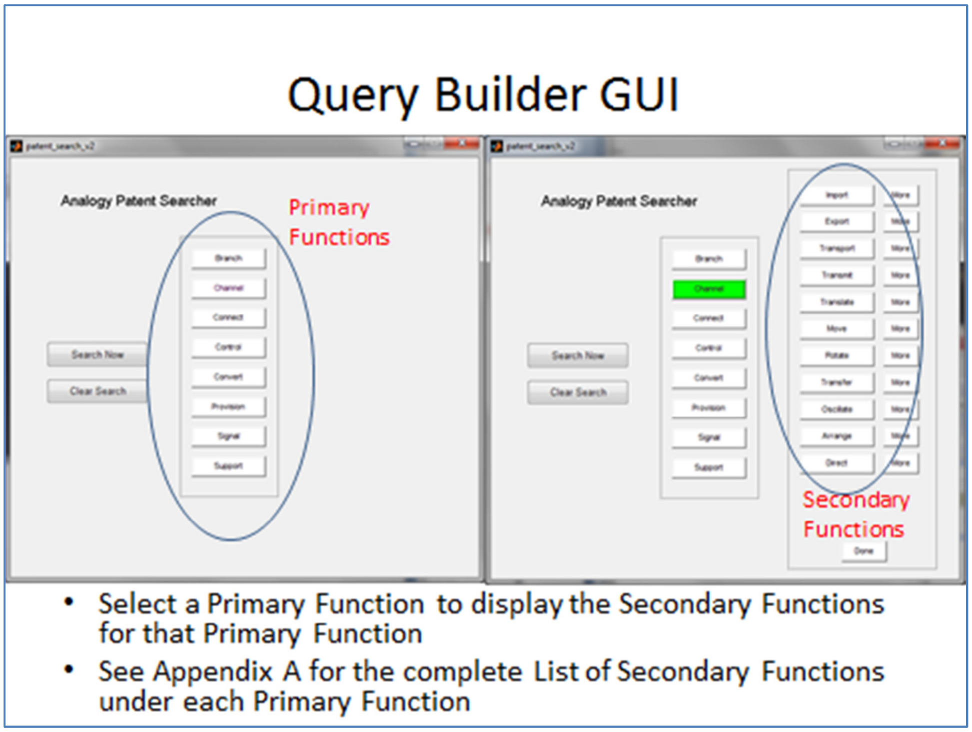


Figure 12. Initial query screen for the Patent Search Engine.

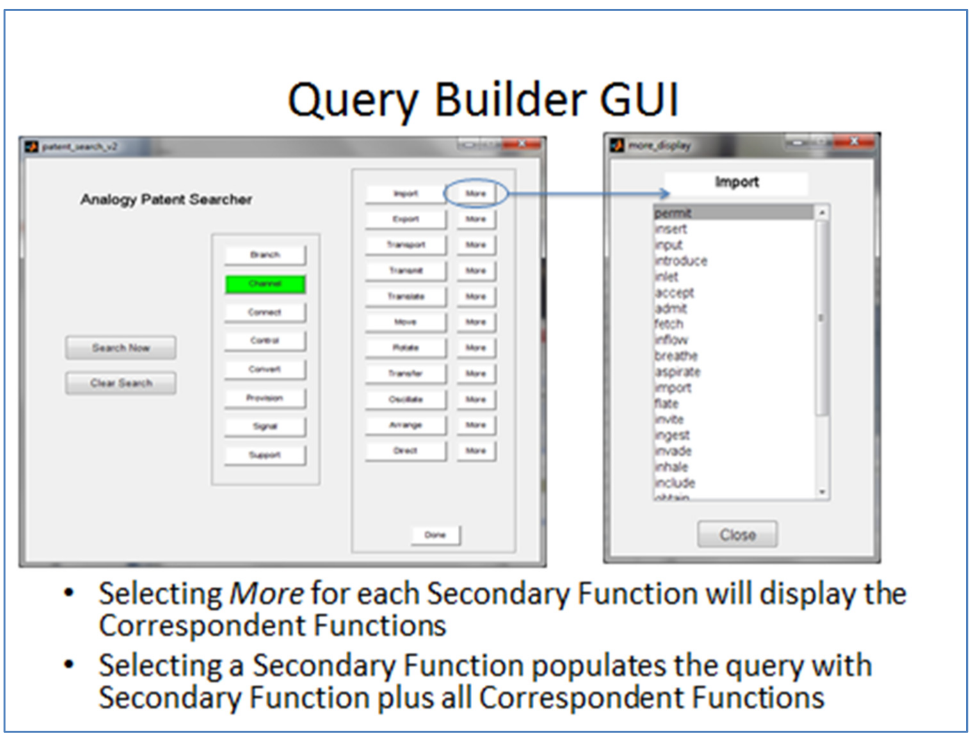


Figure 13. Follow-up query screen for the Patent Search Engine.

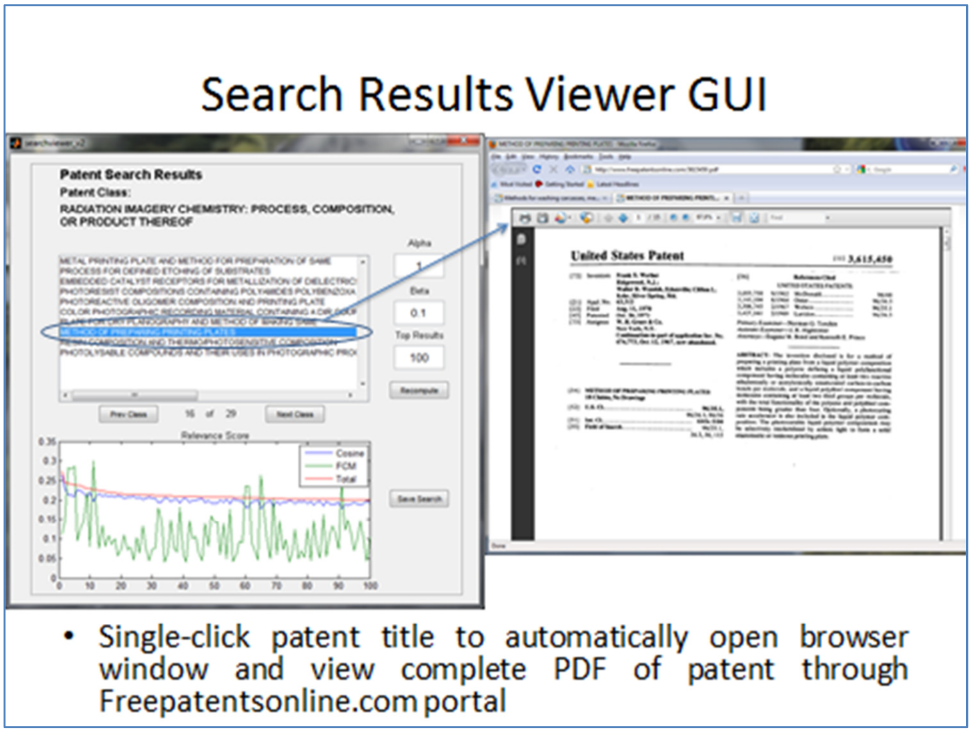


Figure 14. Patent Search Engine final results screen.

4. Assessment

The robotics capstone design (described above) used the four CG techniques early in the 1st semester of their capstone design course. Using these CG techniques, they were able to generate over 130 unique concepts for meeting the design requirements. As it has been established that quantity of ideas generated is positively correlated with quality and novelty [6, 10], the ability of the CG techniques to generate this large space of potential solutions, is seen as a very positive result.

Our assessment has both quantitative and qualitative components. To establish quantitative measures of the effectiveness of the CG tools, students were asked to complete the survey found in Figure 15. Figure 16 shows the numbers of concepts and the percentages associated with the different CG methods. The data indicate that, in terms of ability to generate a large quantity of concepts, the four methods form two groups. The *Make* and 6-3-5 methods both show a statistically significant ($p < .05$) increase in their ability to generate large numbers of concepts over the Patent and *PS/PM* methods. However, note that even the less productive methods were able to significantly increase the overall number of concepts.

Feedback on the Concept Generation Methods

How many different concepts did you personally produce using this method:

Patent Search _________ Pop. Science / Pop. Mechanics ______ Make Magazine ______ 6-3-5 ______

For the questions below, place an "X" next to the response (Strongly Agree through Strongly Disagree) that best describes your assessment of the method

The **Patent Search** method produces very **novel** concepts

Strongly agree Agree Somewhat Agree Neutral Somewhat Disagree Disagree Strongly Disagree

The **Pop. Science / Pop. Mechanics** method produces very **novel** concepts

Strongly agree Agree Somewhat Agree Neutral Somewhat Disagree Disagree Strongly Disagree

The **Make Magazine** method produces very **novel** concepts

Strongly agree Agree Somewhat Agree Neutral Somewhat Disagree Disagree Strongly Disagree

The **Patent Search** method produces concepts that are **feasible**

Strongly agree Agree Somewhat Agree Neutral Somewhat Disagree Disagree Strongly Disagree

The **Pop. Science / Pop. Mechanics** method produces concepts that are **feasible**

Strongly agree Agree Somewhat Agree Neutral Somewhat Disagree Disagree Strongly Disagree

The **Make Magazine** method produces concepts that are **feasible**

Strongly agree Agree Somewhat Agree Neutral Somewhat Disagree Disagree Strongly Disagree

The **Patent Search** method produces concepts that are **easy to use**

Strongly agree Agree Somewhat Agree Neutral Somewhat Disagree Disagree Strongly Disagree

The **Pop. Science / Pop. Mechanics** method produces concepts that are **easy to use**

Strongly agree Agree Somewhat Agree Neutral Somewhat Disagree Disagree Strongly Disagree

The **Make Magazine** method produces concepts that are **easy to use**

Strongly agree Agree Somewhat Agree Neutral Somewhat Disagree Disagree Strongly Disagree

Figure 15. Student survey evaluating the four CG techniques.

	Patent	PS/PM	Make	6 3 5	Sum
# concepts	22	26	44	43	135
AVG %	12.1	20.5	34.1	33.1	100.0

Figure 16. Concepts generated using the four CG techniques.

In order to quantify the responses to the lower portion of the survey in Figure 15, numerical values were associated with the responses. "Strongly Disagree" was given a value of 0 with each response moving to the left increased by 1 unit, so that "Strongly Agree" receives a value of 6. Based on these numerical assignments, the student data can be seen in Figure 17.

	Patent	PS /PM	Make
Novel	2.25	4.00	4.00
Feasible	2.88	4.25	5.00
Easy to use	2.25	4.63	4.88

Figure 17. Measuring novelty, feasibility and ease of use for CG methods.

Note that the students rate the *Make Magazine* method highest across all three assessment categories, followed by the *PS/PM* and then the Patent methods. There is statistical significance ($P<.05$) for the following conclusions:

- Students rate both *PS/PM* and *Make* as creating more novel solutions than the Patent method
- Students rate both *PS/PM* and *Make* as creating more feasible solutions than the Patent method
- Students rate both *PS/PM* and *Make* as being easier to use than the Patent method

It is likely (but not statistically definitive) that they also believe that the *Make* method produces more feasible solutions than the *PS/PM* method ($p = 0.07$).

Note for all these quantitative assessment measures, despite the fact of relatively low p-values, there remain uncontrolled "noise" variables that may make some of the conclusions suspect. A classic example is that the level of the designer's incoming knowledge is not controlled in these experiments. Much like using incoming GPA in educational experiments with control and experimental groups, this incoming knowledge of applicable technology may need to be controlled to enhance the validity of our quantitative assessment results.

Some of the qualitative assessment includes feedback from the faculty on their beliefs regarding the strengths and weaknesses of each of these four CG methods. For example faculty have commented that the 6-3-5 method is efficient and effective in generating potential solutions for almost any design problem. The productivity of this technique has been well documented. The two publication based techniques appear to have some slight differences in applicability. The *PS/PM* method appears to have the greatest effectiveness when the design problem requires significant innovation, but is not as likely to require advanced manufacturing or systems integration techniques. The *Make* technique provides far more detail on manufacturing and systems integration, so is more applicable for those contexts. In addition, this publication has been found to break down some barriers in students' apprehensions regarding development of more advanced electro-mechanical systems simply because the publication provides details of how common problems associated with those types of systems are conquered. The patent search technique has unique benefits as well. Although this method did not produce the quantity of ideas that the 6-3-5 and *Make* methods produced, and although it did not rank as high in terms of "novel", "feasible" and "easy to use" as other methods, it has unique benefits. First, it provides the students with some experience viewing patents; an experience we believe is quite important for engineers. Second, for certain design challenges, it may be evident that patented technology likely exists to address part or all of a particular design requirement. Finally, there are cases where teams are developing technology that they would like to potentially patent. This technique allows them to do an initial investigation to determine if patents already exist that would prohibit them from obtaining their own patent.

The following excerpt is based on a student assessment of the value of each of the 4 CG methods:

"Of the four CG techniques used by our design team, the 6-3-5 method and patent searches were the most beneficial for both my individual research as a team member and I believe, for the overall progress of the team. Our team did not significantly use the *Make Magazine* for CG, but *PS/PM* magazines were passed around the team to facilitate individual research. The individual research by each team member was brought together during our brainstorming to maximize the breadth of ideas in the design space. Overall, these methods were used from the broadest type ideas and funneled down to more specific ideas. In this way, the 6-3-5 method was used as our broadest CG method, while patent searches and *PS/PM* were used more to determine if any similar concepts were already developed further by sources outside of our team.

The 6-3-5 method was used twice within our team throughout the first semester of our capstone design project. Our team slightly modified the 6-3-5 method to include 5 people due to team member constraints. The first time we completed this process, the team generated a number of unique concepts. In addition to these concepts, a general trend to our solutions was identified and helped to narrow the focus of our team onto specific challenges that had to be overcome by the final solution. However, while this narrowed focus was useful in some cases; our team generally had problems with narrowing our focus too quickly. The second time the team used the 6-3-5 method was to solve a more particular problem with one of the more promising identified solutions. Applying the 6-3-5 method for both of these concept generation challenges was very useful, but I feel could have been more effective if some of the concepts could have been described by the person generating the idea. This is due to the difficulty of understanding the idea behind some of the more indiscernible drawings.

The *PS/PM* magazines were less useful because few products were even remotely related to the specific challenges faced by our design team. Perhaps a more exhaustive search within these magazines could have yielded more significant concepts, but with the time our team was able to devote to them, I do not feel they contributed significantly to the team's concept generation."

5. Conclusions and Future Work

The research documented in this paper shows that there are both existing as well as new techniques that can be effectively used to generate creative and innovative ideas to solve engineering design problems. The four techniques presented, *PS/PM* publications, use of the publication *Make*, use of a new patent search tool and use of the 6-3-5 "brain writing – rotational drawing" have been successfully used in a senior capstone design course to improve both the quantity of innovative design solutions as well as enhancing the creativity of the engineering students in the course. For the specific design problem of creating a counter-tunnel robotic system capable of ISR missions this study showed that both *Make* magazine and the 6-3-5 methods each accounted for approximately 33-34% of the total number of design solutions created. Conversely, *PS/PM* and the Patent search methods accounted for 20.5% and 12.1% respectively, of the total number of concepts generated. The four CG methods were also assessed in their ability to provide not only a large quantity of creative solutions but also highly feasible solutions that could progress to the next phase of the design process. An assessment by the design team members showed that the *Make* magazine method generated concepts that were evaluated to be more novel, feasible and easier to use than the other CG methods used.

The findings presented in this paper are not intended to be a thorough quantitative measure of the quality of these four methods. Instead, it is a qualitative introduction to new ideas with a comparison to existing and proven methods with the intent of continuing to assess and improve the methods through future application to design projects requiring innovation in their solution. It is the recommendation of the authors that these methods be given consideration, in conjunction with other known concept generation methods, during the concept generation phase of design. This should be done in a context where features like novelty, feasibility and quality can be quantified using proven techniques based on statistical inter-rater reliability. It is up to the design team and mentor to decide which CG methods are most appropriate for the type of work they are doing. The authors also encourage other design and capstone instructors to try the methods in class and share their results.

Acknowledgements:

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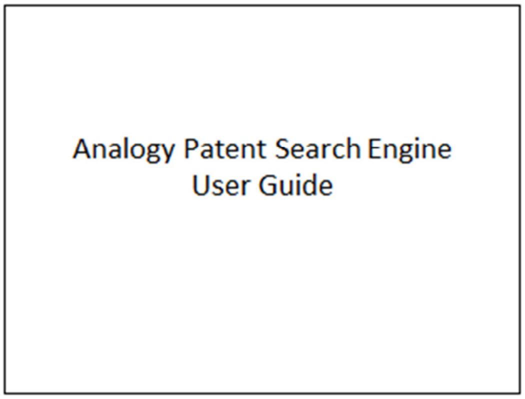
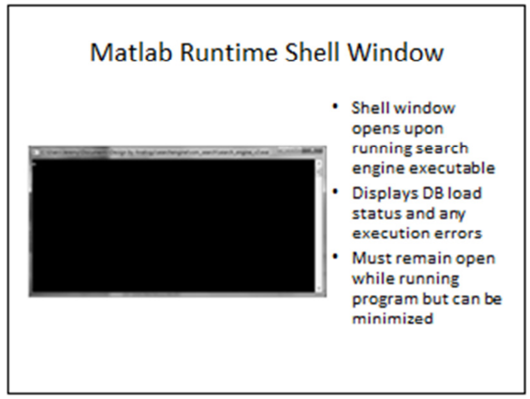
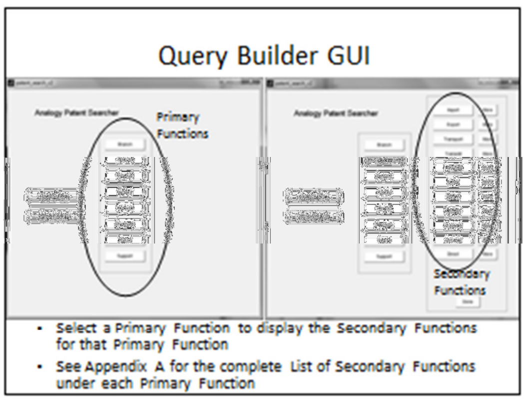
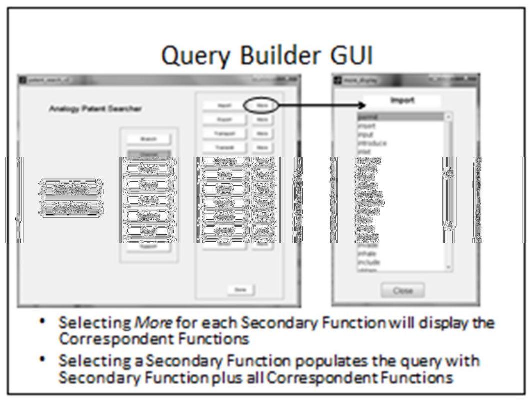
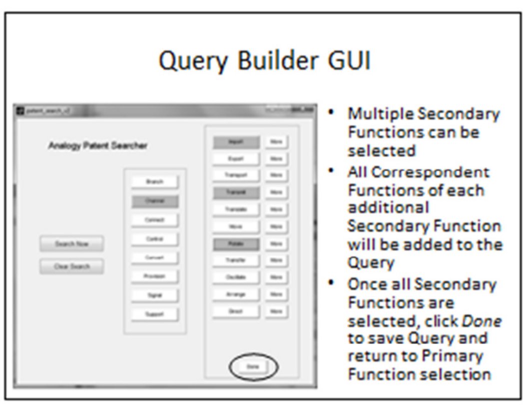
APPENDIX A – Analogy Patent Search Engine User Guide – (copy write Jeremy Murphy)

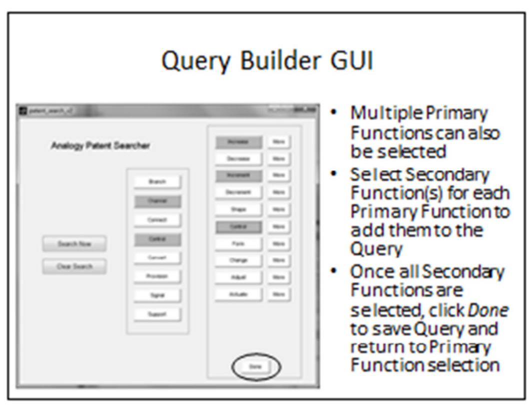












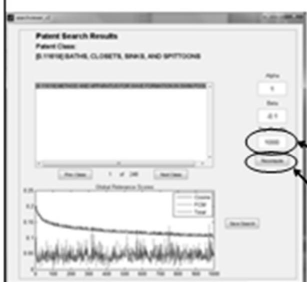
Query Builder GUI

- Select *Search Now* to complete the Query and open the **Search Results Viewer**
- Select *Clear Search* to clear the current Query
- Close this window to completely exit the search program

Search Results Viewer GUI

- **Search Results Viewer** displays top search results grouped by USPTO Patent Classes
- Results Displayed
  - Current Patent Class
  - Patent Title
  - Top Patent Relevance Score Plot

Search Results Viewer GUI



User Controls

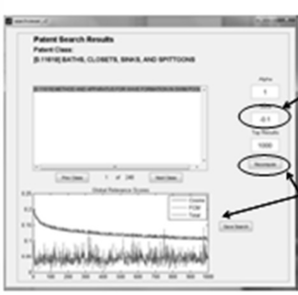
- Top Results
  - Total number of patents to display
  - Default value is top 1000 patents
  - To change value, type in new number and select *Recompute*

Search Results Viewer GUI

User Controls

- Relevance Score Weights, $Score = \boldsymbol{\alpha} \cdot \cos\theta + \beta \cdot FCM$
  - Alpha
    - Weighting coefficient for *Cosine Similarity Metric*, $\cos\theta = \frac{Query \bullet Patent}{\|Query\| * \|Patent\|}$
    - Default value is 1
    - To change value, type in new number and select *Recompute*

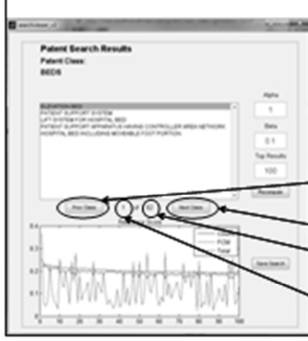
Search Results Viewer GUI



User Controls

- Relevance Score Weights, $Score = \alpha \cdot \cos\theta + \boldsymbol{\beta} \cdot FCM$
  - Beta
    - Weighting coefficient for *Functional Content Metric*, $FCM = \frac{\sum Patent}{NumTerms}$
    - Default value is -0.1
    - To change value, type in new number and select *Recompute*

Search Results Viewer GUI



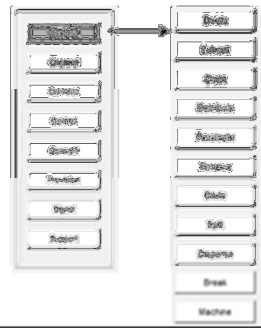
User Controls

- Patent Class Scroll Controls
  - Scroll though patent classes to view all search results
  - *Previous Class* Button
  - *Next Class* Button
  - Total number of patent class groups
  - Current class index

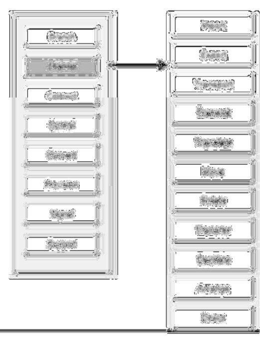
Search Results Viewer GUI

- Single-click patent title to automatically open browser window and view complete PDF of patent through Freepatentsonline.com portal

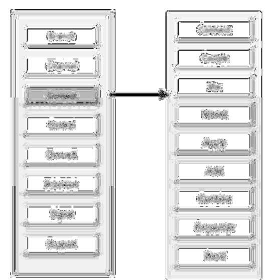
Appendix A: Branch



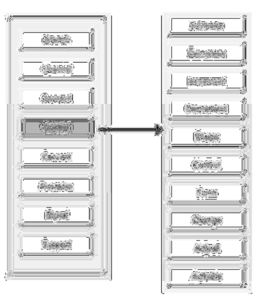
Appendix A: Channel



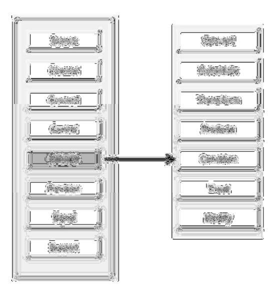
Appendix A: Connect

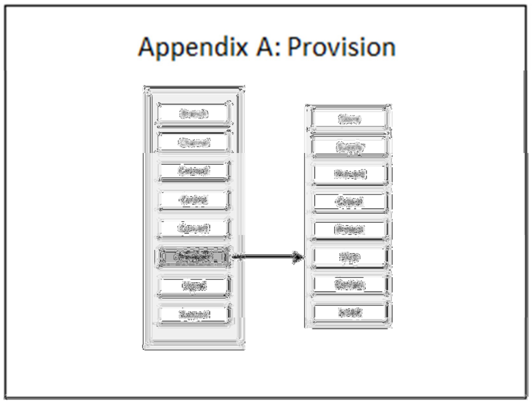


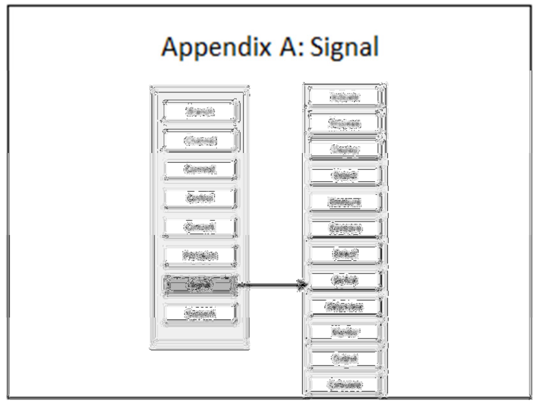
Appendix A: Control

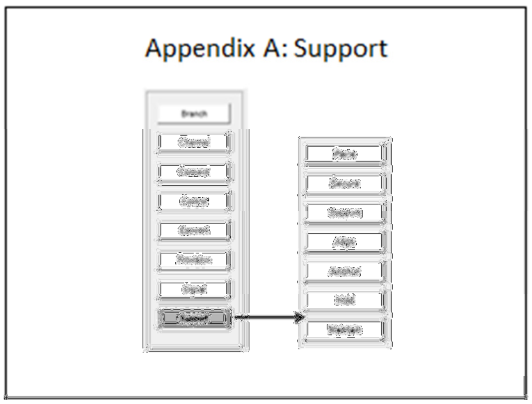


Appendix A: Convert




Appendix A: Provision


Appendix A: Signal


Appendix A: Support
Branch