“We are the scientists, trying to make sense of the stars inside us.”

-Christopher Poindexter
A Jungian–based framework for artificial personality synthesis

David Mascareñas
Los Alamos National Laboratory
Engineering Institute
LA-UR-16-27052

“The meeting of two personalities is like the contact of two chemical substances: if there is any reaction, both are transformed.”

-Carl Jung-
“Teams that had it basically wrong — but for a few good ideas — made the difference when combined with teams which had it basically right, but couldn’t close the deal on their own.”

“Then there was a great insight among some of the teams — that if they combined their approaches, they actually got better. It was fairly unintuitive to many people [because you generally take the smartest two people and say ‘come up with a solution’]... when you get this combining of these algorithms in certain ways, it started out this ‘second frenzy.’ In combination, the teams could get better and better and better.”

“Ironically, the most outlying approaches — the ones farthest away from the mainstream way to solve a given problem — proved most helpful towards the end of the contest, as the teams neared the summit.”

Buskik, Eliot Van, “How the Netflix Prize was Won,” Wired, 9/22/09.
Current computational personality research is dangerously homogenous.

**The Big 5**

*Openness, Conscientiousness, Extroversion, Agreeableness, and Neuroticism.*

“Trait based models are widely accepted in the computing community as well. All of the works surveyed in this article adopt personality traits (the BF in 76 cases out of 81) and, to the best of our knowledge, no other theories were ever adopted in computing oriented research. On one hand, this barely reflects the dominant position of trait based models in personality psychology. On the other hand, trait models represent personality in terms of numerical values, a form particularly suitable for computer processing. [1].”


The problem with this is that experience and research have shown that solving problems is generally aided by being able to combine diverse ways of approaching the problem.

This is how the Netflix prize was won.
“Loneliness does not come from having no people about one, but from being unable to communicate the things that seem important to oneself, or from holding certain views which others find inadmissible.” – C.G. Jung
**Overview of the Jungian Personality Model**

- Modern Incarnation is Meyers Briggs Type Indicator

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### Archetypes

<table>
<thead>
<tr>
<th>ISTJ</th>
<th>ISFJ</th>
<th>INFJ</th>
<th>INTJ</th>
</tr>
</thead>
<tbody>
<tr>
<td>Responsible, sincere, analytical, reserved, realistic, systematic. Hardworking and trustworthy with sound practical judgment.</td>
<td>Warm, considerate, gentle, responsible, pragmatic, thorough. Devoted caretakers who enjoy being helpful to others.</td>
<td>Idealistic, organized, insightful, dependable, compassionate, gentle. Seek harmony and cooperation, enjoy intellectual stimulation.</td>
<td>Innovative, independent, strategic, logical, reserved, insightful. Driven by their own original ideas to achieve improvements.</td>
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<tr>
<td>Action-oriented, logical, analytical, spontaneous, reserved, independent. Enjoy adventure, skilled at understanding how mechanical things work.</td>
<td>Gentle, sensitive, nurturing, helpful, flexible, realistic. Seek to create a personal environment that is both beautiful and practical.</td>
<td>Sensitive, creative, idealistic, perceptive, caring, loyal. Value inner harmony and personal growth, focus on dreams and possibilities.</td>
<td>Intellectual, logical, precise, reserved, flexible, imaginative. Original thinkers who enjoy speculation and creative problem solving.</td>
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<td>Efficient, outgoing, analytical, systematic, dependable, realistic. Like to run the show and get things done in an orderly fashion.</td>
<td>Friendly, outgoing, reliable, conscientious, organized, practical. Seek to be helpful and please others, enjoy being active and productive.</td>
<td>Caring, enthusiastic, idealistic, organized, diplomatic, responsible. Skilled communicators who value connection with people.</td>
<td>Strategic, logical, efficient, outgoing, ambitious, independent. Effective organizers of people and long-range planners.</td>
</tr>
</tbody>
</table>

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**Cognitive Functions**

- Myers-Briggs Types - Jake Beech
  https://en.wikipedia.org/wiki/File:MyersBriggsTypes.png

- Cognitive Functions – Jake Beech

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“Everything that irritates us about others can lead us to an understanding of ourselves.”

-Carl Jung
Overview of the Jungian Personality Model
-Cognitive Functions Hierarchy

Cognitive Functions are the Basic Building Blocks of the Jungian Personality Theory

The Jungian model is not Cartesian in Nature

In the Jungian/MBTI model everyone has access to all eight of the cognitive functions. The difference between the personality archetypes is the preference order for using the cognitive functions.

Personal Preferred Reference on the topic:

Overview of the Jungian Personality Model - Cognitive Function Preference Order

Constraints on the first 4 cognitive functions:
1. The functions alternate between an introverted and extroverted attitude
2. The 1st and 4th function must both either be judging or perceiving functions. The 1st and 4th functions have opposite attitude and must be the opposite with respect to the type of judging or perceiving function the other is.
3. The 2nd and 3rd functions have the same constraints as the 1st and 4th cognitive functions.

Personal Preferred Reference on the topic:
Jungian Framework Overview
How to build a Jungian Artificial Personality

- Algorithms that have been developed for a variety of applications (e.g. Principle Components Analysis, Artificial Neural Networks, Linear Classifiers, etc.) can be mapped to the cognitive functions that make up the building blocks of the Jungian personality model. These algorithms can be used to implement the cognitive functions.

- Human personality is inherently serial in nature. Human personality arises from the limitation that humans can only use one cognitive function at any given time. Or at least the human ability to use more than one function at a time appears to be severely limited.

- The Jungian type-based personality framework allows for the possibility of an individual agent to use any of the 8 cognitive functions at any given time, however, personality emerges from a hierarchical preference for certain cognitive functions over others. The order and magnitude of preference can be selected based on models such as the Myer & Briggs cognitive function orders [4]. They could also possibly be learned from data, or could even be chosen arbitrarily. Initially the authors suggest using the Myers & Briggs cognitive function orders as guidance.

Personality as we perceive it is a phenomena that is just about weakness, mistakes, and oversights as it is about our strengths. Personality emerges from our limitations.
Overview of the Jungian Personality Model
-The Judging Cognitive Functions

**Extroverted Thinking**

- Contingency planning, scheduling, and quantifying utilize the process of extraverted Thinking.
- Extraverted Thinking helps us organize our environment and ideas through charts, tables, graphs, flow charts, outlines, and so on. At its most sophisticated, this process is about organizing and monitoring people and things to work efficiently and productively.

**Extroverted Feeling**

- The process of extraverted Feeling often involves a desire to connect with (or disconnect from) others and is often evidenced by expressions of warmth (or displeasure) and self-disclosure.
- The "social graces," such as being polite, being nice, being friendly, being considerate, and being appropriate, often revolve around the process of extraverted Feeling.

### Algorithmic implementation examples

- Partially Observable Markov Decision Process
- A*
- Optimization routines
- Linear Programming
- Use own embodiment as analog computation based on perception of external affect
- Artificial Neural Networks
- Resources allocated weighted towards communications/collaboration with other agents (human, machine and otherwise)
- State of health evaluation of other agents
- Cost functions for optimization designed in such a way that rewards associated with group success outweigh individual rewards associated with individual success
- Analysis of how actions will affect group well-being

"Where wisdom reigns, there is no conflict between thinking and feeling."

— C.G. Jung

http://www.cognitiveprocesses.com/Cognitive-Functions/
Overview of the Jungian Personality Model
-The Judging Cognitive Functions

<table>
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<tr>
<th>Introverted Thinking</th>
<th>Introverted Feeling</th>
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</table>
| ![Image](image1.png) | “what care I, love, that thou be wise?
be fair! be sad! for tears contain
an added charm in lovely eyes,
like vales a river glorifies;
the rose is fresher in the rain.”
- Charles Baudelaire, Madrigal Triste, Fleurs Du Mal |

Introverted Thinking often involves finding just the right word to clearly express an idea concisely, crisply, and to the point. Using introverted Thinking is like having an internal sense of the essential qualities of something, noticing the fine distinctions that make it what it is and then naming it.

**Algorithmic implementation examples**

- Decomposition Algorithms
- Principle Components Analysis
- Independent Components Analysis
- Sparse Dictionary Learning
- Auto Associative Neural Networks
- Artificial Neural Networks
- Techniques for state of health monitoring of self.
- Cost functions for optimization designed in such a way that individual rewards for individual success outweigh group rewards associated with group success
- Analysis of how actions will affect individual well-being
Overview of the Jungian Personality Model
-The Perceiving Cognitive Functions

**Extroverted Sensing**

Extroverted Sensing occurs when we become aware of what is in the physical world in rich detail. We may be drawn to act on what we experience to get an immediate result. Extraverted Sensing is operating when we freely follow exciting physical impulses or instincts as they come up and enjoy the thrill of action in the present moment.

**Extroverted Intuition**

Extraverted iNtuiting involves noticing hidden meanings and interpreting them, often entertaining a wealth of possible interpretations from just one idea or interpreting what someone's behavior really means. It also involves seeing things "as if," with various possible representations of reality. (Stream of Consciousness)

**Algorithmic implementation examples**

- Active learning
- Active SLAM
- Online Learning
- Search based on maximum information gain
- PID control
- Search Engines
- Compressive Sampling
- Random Walk
- Genetic Algorithms
- Wide band filtering on input. All data gets through.

http://www.cognitiveprocesses.com/Cognitive-Functions/
Overview of the Jungian Personality Model
-The Perceiving Cognitive Functions

**Introverted Sensing**

Introverted Sensing often involves storing data and information, then comparing and contrasting the current situation with similar ones. The immediate experience or words are instantly linked with the prior experiences, and we register a similarity or a difference—for example, noticing that some food doesn't taste the same or is saltier than it usually is.

**Introverted Intuition**

Introverted Intuiting involves synthesizing the seemingly paradoxical or contradictory, which takes understanding to a new level. Using this process, we can have moments when completely new, unimagined realizations come to us.

**Algorithmic implementation examples**

- Supervised learning
- Support Vector Machine Classification
- Matched filtering
- Narrowband filtering
- Autocorrelation
- Cross correlation
- Simulation/Prediction (e.g. FEA, CFD)
- Design of Experiment
- Autocomplete
- System ID
- Interpolation/Extrapolation
- Bayesian Inference

http://www.cognitiveprocesses.com/Cognitive-Functions/
Jungian Framework Implementation Example

ENFJ

Bias for Data Sharing and Networking

AR models

Principle Component Analysis

Active Learning

By photo by Alan Light, CC BY 2.0, https://commons.wikimedia.org/w/index.php?curid=1131224
The Genotype and Phenotype Perspective/Analogy Linking the Jungian and Big-5 model

<table>
<thead>
<tr>
<th>Genotype</th>
<th>Phenotype</th>
</tr>
</thead>
<tbody>
<tr>
<td>(the genetic constitution of an individual organism.*)</td>
<td>(the set of observable characteristics of an individual resulting from the interaction of its genotype with the environment.*)</td>
</tr>
<tr>
<td><strong>Jungian Personality</strong></td>
<td></td>
</tr>
<tr>
<td>• Model</td>
<td><strong>Big 5</strong></td>
</tr>
<tr>
<td>• Born with a given Jungian personality archetype. Underlying Jungian personality does not change with age.</td>
<td>• Data-Driven</td>
</tr>
<tr>
<td>• For each archetype a bias for a given temporal pattern of behavior change with age is provided. This change is driven by the development of lower cognitive function.</td>
<td>• Snapshot in time of current personality traits</td>
</tr>
<tr>
<td></td>
<td>• Personality and behavior traits can change as a result of life experiences.</td>
</tr>
</tbody>
</table>

Two people can have the same Jungian archetype but exhibit significantly different behavior.

The Jungian and Big-5 views are not mutually exclusive.

“Life really does begin at forty. Up until then, you are just doing research.”
Carl G. Jung

*Google dictionary
A start towards Jungian Artificial Personality Synthesis (With Sebastian Zanlongo (FIU))

- Agents exhibit a single cognitive function
  - Feeling Extraverted – Copy other Agent’s map into own
  - Feeling Introverted – Find most preferred location in environment
  - Thinking Extraverted – SVM predicts best locations
  - Thinking Introverted – Dimensionality reduction saves memory
  - Intuition Extraverted – Evolutionary algorithm
  - Intuition Introverted – Gaussian Naïve Bayes predicts food locations
  - Sensation Extraverted – Seek out most unexplored area
  - Sensation Introverted – SGD Classifier predicts food locations
A start towards Jungian Artificial Personality Synthesis (With Sebastian Zanlongo (FIU))

- Describe an Environment and Agents to demonstrate cognitive functions
- Environment has multiple features and behaviors
  - Walls and water (block movement, visibility)
  - Terrain (movement cost)
  - Food (good, poisonous), surrounded by a scent gradient
A start towards Jungian Artificial Personality Synthesis (With Sebastian Zanlongo (FIU))

Extroverted Intuition
A start towards Jungian Artificial Personality Synthesis (With Sebastian Zanlongo (FIU))
A start towards Jungian Artificial Personality Synthesis (With Sebastian Zanlongo (FIU))

ENTP – ENFP – ESFJ – ENFJ
Questions?
Overview of the Jungian Personality Model
-Misconceptions and clarifications

- Jungian/MBTI framework is not either/or. Everyone has access to and uses all of the cognitive functions. Personality differences arise from the order of preference different people have for the cognitive functions.

- In the Jungian/MBTI model

- The Junginian/MBTI personality tests have a number of weaknesses. I make no claim the the tests themselves are sound. I suggest non-survey based methods be developed. (Remco Chang’s work is relevant)
ADHD – A Evolutionary Advantage?

Eisenberg explains, "The DRD4/7R allele has been linked to greater food and drug cravings, novelty-seeking, and ADHD symptoms. It is possible that in the nomadic setting, a boy with this allele might be able to more effectively defend livestock against raiders or locate food and water sources, but that the same tendencies might not be as beneficial in settled pursuits such as focusing in school, farming or selling goods".
But these skills have questionable value today

“The surprise came at the conclusion of the event. The winner was revealed to be not a grandmaster with a state-of-the-art PC but a pair of amateur American chess players using three computers at the same time. Their skill at manipulating and “coaching” their computers to look very deeply into positions effectively counteracted the superior chess understanding of their grandmaster opponents and the greater computational power of other participants. Weak human + machine + better process was superior to a strong computer alone and, more remarkably, superior to a strong human + machine + inferior process.”

-Garry Kasparov
Current computational personality research is dangerously homogenous.

**The Big 5**

Openness, Conscientiousness, Extroversion, Agreeableness, and Neuroticism.

“Trait based models are widely accepted in the computing community as well. All of the works surveyed in this article adopt personality traits (the BF in 76 cases out of 81) and, to the best of our knowledge, no other theories were ever adopted in computing oriented research. On one hand, this barely reflects the dominant position of trait based models in personality psychology. On the other hand, trait models represent personality in terms of numerical values, a form particularly suitable for computer processing. [1].”


The problem with this is that experience and research have shown that solving problems is generally aided by being able to combine diverse ways of approaching the problem.

This is how the Netflix prize was won.
Modern hunter-gatherer - Miami

Miami, Florida, Photo Courtesy of David Whalen, La Mancha Media
I remembered my machining days...

"The faculty known as the sense of touch that enables the operator of a hand-screw machine to follow, by the ‘feel’ of his lever .... serves as an accurate medium by which the operator .... may gage the action of the cutter which he feeds his work."
The modern hunter-gatherer – New Mexico
Current computational personality research is dangerously homogenous.  

**The Big 5**  
Openness, Conscientiousness, Extroversion, Agreeableness, and Neuroticism.

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The problem with this is that experience and research have shown that solving problems is generally aided by being able to combine diverse ways of approaching the problem.

This is how the Netflix prize was won.
Artificial Personality Synthesis: Leveraging Diversity to enable robust robotic teams.

Over the course of the last 4 years I have been developing an alternative approach to the computational personality problem.

My approach incorporates a “type-based” personality model as opposed to being purely “trait-based.”

My approach is inspired by Jungian, type-based personality theory.

- Personality is modelled in terms of 8 cognitive functions. All people have access to all 8 functions, however different “types,” of people have different orders of preference to use the functions. A person can only use one cognitive function at a time and there are constraints on the preference order of the functions.
- The key insight is that the cognitive functions can be implemented using known algorithms.
- Cognitive functions can be combined in the form of a state machine.
Most widely accepted model for personality is the Five Factor Model. The problem is that it is purely data-driven and does not suggest any method using existing algorithms to build a machine with a personality that is easier for humans to interact with. It is also, linear and Cartesian in nature?

It also really give no clue or theory as to how we can replicate personality artificially.
### Algorithms map to Jungian cognitive functions

<table>
<thead>
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<tr>
<td>POMDP, A*, Kalman Filter, Model Updating?</td>
<td>PCA, ICA, Hierarchical Deep Learning, Auto-Associative Neural Nets</td>
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<td>An active seeking of more and more input to get the whole picture may occur until all sources of input have been exhausted or something else captures our attention.</td>
<td>Introverted Sensing often involves storing data and information, then comparing and contrasting the current situation with similar ones.</td>
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<tr>
<td><strong>Active Sensing Algorithms, (Consider the active learning algorithms from Cornell)</strong>, Maximize Information Gain, Active SLAM, Online Learning, Unsupervised Learning (Maybe)</td>
<td><strong>Pattern Matching and Classification Algorithms. Supervised Learning.</strong> It is kind of like taking previously stored data and replaying it through the system to determine the reaction.</td>
</tr>
</tbody>
</table>
Algorithms map to Jungian cognitive functions

**Extroverted Feeling ()**
The process of extraverted Feeling often involves a desire to connect with (or disconnect from) others and is often evidenced by expressions of warmth (or displeasure) and self-disclosure.

*State-of-health monitoring, NDE, Affective Computing*

**Introverted Feeling()**
As a cognitive process, it often serves as a filter for information that matches what is valued, wanted, or worth believing in.

**Neural Networks?**

**Extroverted Intuition()**
Using this process we can really appreciate brainstorming and trust what emerges, enjoying imaginative play with scenarios and combining possibilities, using a kind of cross-contextual thinking.

*Search Engines do this. They bring varieties of ideas together that are somewhat loosely related.*

**Introverted Intuition ()**
This process can involve working out complex concepts or systems of thinking or conceiving of symbolic or novel ways to understand things that are universal. I think this is executed by nearly all simulations and possibly optimization algorithms and genetic algorithms. Design of experiment as well. People who are strong Ni users tend to fall prey to “Analysis Paralysis”, Autocomplete,
Chain it all together in a graphical network

Consider alternatives to the Cartesian thinking suggested by the 5 Factor Model. Consider a graphical network model.

Research on distracted driving suggests that humans really cannot multi-task. This suggests that human thought is more like a state machine.

Further more, recent research by Jack 2012, shows that the analytic and empathetic parts of the brain inhibit one another.

Each state represents a different processing or information gathering function. There is a preference order for the states. This is personality.
Enhanced Situational Awareness
Questions?
Overview of the Jungian Personality Model
-The Judging Cognitive Functions

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Introverted Thinking often involves finding just the right word to clearly express an idea concisely, crisply, and to the point. Using introverted Thinking is like having an internal sense of the essential qualities of something, noticing the fine distinctions that make it what it is and then naming it.

The process of extraverted Feeling often involves a desire to connect with (or disconnect from) others and is often evidenced by expressions of warmth (or displeasure) and self-disclosure. The "social graces," such as being polite, being nice, being friendly, being considerate, and being appropriate, often revolve around the process of extraverted Feeling.

It is often hard to assign words to the values used to make introverted Feeling judgments since they are often associated with images, feeling tones, and gut reactions more than words. As a cognitive process, it often serves as a filter for information that matches what is valued, wanted, or worth believing in.

"Where wisdom reigns, there is no conflict between thinking and feeling.”
— C.G. Jung

http://www.cognitiveprocesses.com/Cognitive-Functions/
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