**Feed-Forward Subsumption Archetypical Stack**

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# Psychology Background

For those with interest in the comparison of this project, the subsumption architecture, with the psychology of C.G. Jung and Sigmund Freud I’ve elaborated briefly in this section. For those not interested you may skip to section 5 without any loss of information. This is simply optional background material and not necessary to understand the project in general. In order to introduce the modifications made to the subsumption architecture’s stack, some references can be made to the models of the mind generated by early psychologists who actually founded the field. Both Sigmund Freud and Carl Jung helped create the field we know today and each had their own idea of a model of the brain. Sigmund Freud’s model is known as the “iceberg” model in that he viewed the conscious mind to be like a tip of an iceberg, with a superego and ego exposed. The superego being in charge with high-level functions like planning, setting goals, and self-image and the ego being the conscious mind capable of everyday thought. Below the “waters” of this so called iceberg existed a subconscious, where the super ego also extended to but in which also existed a part of the mind known as the id: responsible for more animalistic and primitive functions such as desire for food, pain, reflexes, instincts, etc. The combination of the id and superego formed the motivations for the actions of the conscious mind, the ego.

Carl Jung, a pupil of Sigmund, developed his own theory of the unconscious that contained a model similar to Freud’s model, but also contained archetypes or complexes, as they are sometimes referred to. These archetypes were present, Jung reasoned, because they existed across all cultures. Jung also delved into some mysticism in his theories of a collective unconscious, but those are outside the scope of this paper.

Super-ego

Id: Primal/Reflexes

Resurfacing

Repression

**Freud’s Iceberg Model**

Above is Freud’s model of the mind, with the subconscious lying below the wavy line and conscious mind above. Jung further postulated that there existed “Archetypes” deeper into the subconscious. These archetypes were universal across cultures and were members of a collective unconscious.

To the left and right of the iceberg are arrows representing the suppression/resurfacing of parts of the mind: thoughts, ideas, behaviors, personalities, etc. The deeper into the subconscious one goes, the more primal and reactive behaviors one finds. These behaviors interact to surface as individual thoughts in the conscious mind.

# Background on Psychology as related to Subsumption Architecture

The subsumption architecture developed by Rodney Brooks resembles a somewhat tapered stack. From here on out we will assume it has the properties of both a priority queue, allowing us to move behaviors up and down the “stack.” The subsumption architecture shares a few common attributes with Freud’s iceberg model. Both models, despite the fact Brook’s model is for simple robots of intelligence not much greater than that of an insect, share common parallels. At the lower level of Freud’s iceberg exist the mind’s most basic and necessary needs for life and survival. The same occurs in Brooks’ subsumption architecture, where the reflex like behaviors are on the bottom of the stack and will takeover in cases of danger or other cases where reflex like actions is necessary. Brook’s architecture has the higher-level functions of the robot’s “mind” (to use the term loosely), can be subsumed by the lower parts, and sit higher in the architecture. The higher functions of both the robot’s mind in Brook’s model and the higher functions of the human’s mind in Freud’s model both are subsumed by lower levels of the stack in times of emergency and the two models are very closely coupled when taken to comparison.

Brook’s model however is static, where Freud’s iceberg model allowed for the suppression and release of certain thoughts or behaviors. This is not present in Brook’s model and is the first modification this work will apply. An example why this is necessary can be presented in the frame of reference of RoboCup soccer. Let us assume that two bots are approaching the goal. The original plan for the first bot is to attempt to shoot to make a goal. However, suddenly the second bot comes into range and it is more advantageous to pass to this player. However, because Brook’s architecture is static, several different levels may separate the two behaviors and one will not be able to subsume the other. Using the concept of “suppression” that Freud introduced in his iceberg model, we could push the one behavior for the bot downwards and suppress it, and “release” the other behavior, bringing it upwards along the stack. This movement up and down the stack, suppression and release of thoughts and behaviors, makes the stack dynamic.

Also, we should consider the additions of archetypes made by Jung to the idea of the unconscious. Although Jung hypothesized his archetypes to occur in the unconscious, it seems from the subsumption model that using them in a different fashion may be more advantageous. For example, treating these archetypes, such as the “Mother”, or the “Child”, or a leadership type, as aggregates of weights on known/planned behaviors. For example, the archetype of Child may have a heavier weight on its “following” traits in the architecture, making it more likely to follow other players than say, a leadership archetype that would spend more time chasing after the soccer ball than assisting other players. The archetype of “Mother” may essentially “mother” another player, spending more time on playing defense of a single or multiple specific players. *These archetypes are primarily the decision makers and* *represent* *both personality and behavior.* An archetype will personify a certain series of traits, such as with the Mother archetype, more heavy weights in the defense parameters. The personality traits are determined by the weights of certain parameters. *When it is time to make a decision, these archetypes and their* *weighted behaviors, with each archetype representing a behavior, all contribute to the central decision-making process*. *The convergence of this decision making process among archetypes forms the conscious decision is the action the agent takes.*

In the simulation there are multiple parameters that would compose the behavior of each player, and the Jungian archetypes essentially give names and inspiration for different strategies for each agent to adopt. Also, more heavily weighted behaviors or strategies would carry a heavier priority when moving upwards or downwards along the stack. These archetypes could also be more simple, defined as simple behaviors, such as “chase the ball”, “block player x”, or “shoot to goal.” The complexity of the archetypes vary per archetype.

Mapping

Wandering

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Simple, reactive behaviors (reflexes)

**Subsumption Architecture**

This is an example model of Brook’s subsumption architecture. Note that, like in Freud’s Iceberg model, the conceptualization as we progress from the lower layers to the upper layers become more complex and as in a human being, the reactive layers subsume (take over) the higher level behaviors if necessary (pain reactions, fight/flight behavior, etc.) Except, it begs the question, where is the “conscious” and “subconscious” in the subsumption architecture? Or is it even possible for this type of division.

The first medication we shall make to the subsumption architecture is the ability to move behaviors from layer to layer, that is, suppress or resurface behaviors. Take for instance the case of two robots playing soccer on the same team. Consider a configuration where one robot approaches the goal with the ball and is ready to shoot. Then suddenly, the team mate has approached the goal and is closer and has a better shot. We would want the behavior to pass to the team mate to override the behavior to kick the ball to the goal. This is not possible in a static architecture. Therefore, we grant the “behaviors” as we will call them for the time being to be able to be suppressed or released along the stack.

One of the major flaws of Brook’s architecture is the periodic deliberation that occurs because of conflicts within layers. Suppose the architecture is not composed of individual behaviors, but of simple agents that can communicate with each other. This is similar to Jung’s model of Archetypes. Assuming each level has multiple Archetypes that are able to communicate and interact, each its own personality and able to make decisions. These Archetypes would be able to make decisions through agent to agent communication, passing those decisions upward along the stack.

Suppose each of these Archetypes has its own behaviors and its own personality beased off of a series of universal parameters. When it is time to make a decision, all the Archetype agents cooperate to come to a final decision. In fact, the structure of the communication and compromise between the agents is based off of a feed-forward network.

Below the is the proposed “Archetypical Architecture Stack”:

Incease in Priority Queue

Decrease in Priority in Queue

**Archetypical Stack**

In the above “Archetypical Stack”, each circle represents an instance of an Archetype. The interactions between the archetypes, resulting on the archetype on a higher level of the stack displays its “feed-forward” nature and also the mediation between behaviors. The archetypes communicate with each other to arrive at decisions; lower, more reactive and primal behaviors in a higher multitude than upper, more complex and abstract behaviors. The most important thing is the red circle at the very top, which represents the convergence point of all the decisions, the so-called “conscious” decision the stack has arrived at. This singular decisions is the result of all the compromises of subconscious archetypes.

# Subsumption Archetypical Stack Design Hypothesis

I am hoping that because of the use of the archetypes, each robot will present itself differently and with a slightly different “personality,” than other bots playing. Varying the assigned archetypes (changing the weights on certain behaviors) I hope will cause different social behaviors to emerge. Social behaviors being, for example where there may be many “Child” archetypes a follow the leader type environment where the Child archetypes follow one bot, playing defense to protect that one bot when it has the ball, and mimicking enemy bots behavior when they have possession. Another example would be a “Leader” archetype along with child archetypes, and mother archetypes. I predict the mother archetypes will play strong defense over the child archetypes, and the child archetypes will follow the leader archetypes. A stated in section 4, an archetype will represent cooperative decision makers in order to solve the internal conflicts experienced in subsumption architecture. The archetypes themselves contain both personality and behavior. For more information on the archetypes and their possible behaviors see the end of section 4.

# Implementation

**Architecture**

Pass decision up stack (feed-forward data)

Suppress behavior down stack (move down stack)

Resurface behavior up stack (move up stack)

**Design**

Archetypes consists of communication methods, parameters defining their personality, and when communicating (socially interacting) with other archetypes interacting to determine behavior.

**Behaviors**

Chase the soccer ball

Defend player x on your team

Defend against player y on enemy’s team

Kick soccer ball towards goal

Pass to player x on your team

Mimic behavior of player x on your team

Mimic behavior of player y on enemy’s team

**Archetypes (collection of parameters causing behaviors)**

Leader (aggressive)

Mother (defensive of players on own team)

Child (follower, mimics often, attempts to learn behaviors)

**Parameters**

Offense Parameter

Defense Parameter

**Robocup Functions**