

**EQUALIZING, COMPLEMENTARY, HEURISTIC ORIENTATION
OF SITUATED AGENTS**

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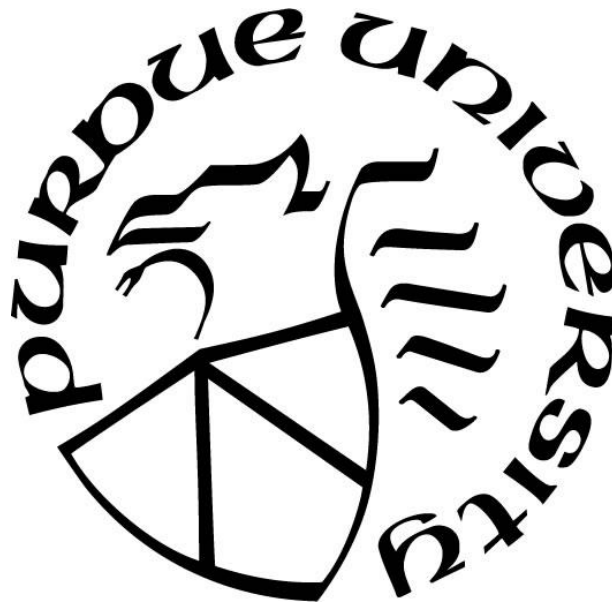
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LIST OF ABBREVIATIONS

AI	Artificial Intelligence
BDI	Belief-Desire-Intention
DAI	Distributed Artificial Intelligence
EMIL-A	EMIL Internalizer Agent
KSA	Korean Saam Acupuncture
MAS	Multi-Agent Systems
MINDSPACE	Messenger, Incentives, Norms, Defaults, Salience, Priming, Affect, Commitment and Ego
PVS	Primo Vascular System
TKM	Traditional Korean Medicine

GLOSSARY

Affective Computing	For the scope of this study, not discussing how to recognize emotions but “having emotions” to be adaptive and the traits developed by having emotions.
Autonomy	The self-governance and self-interests.
Bagua	Third dimensional shift of the yin-yang where a body contains a definitive quality exclusive from another body.
Believable agents	Similar concept to anthropomorphism; in AI, human-like expressions of artificial intelligence.
Bounded rationality	Organisms’ limited capacity to represent the world around.
Ecological rationality	appears when the structure of boundedly rational decision mechanisms matches the structure of information in the environment
Embodiment Thesis	The embodiment movement in artificial intelligence has fueled the embodiment argument in philosophy and a revised view of ethology. “Species-typical activity patterns must be thought of as emergent phenomena in three different senses of the world. They have emerged...through natural selection ...by a process of maturation and/or learning ...and from interactions between the creature’s low-level activities and its species-typical environment.” (Horst Hendriks-Jansen <i>Catching Ourselves in the Act</i> , p. 10).
Memes	the smallest chunk of knowledge
Meridian	the energy paths in the body to connect the soma links to perceptions
Meridian Consciousness	in the twelve paths of Meridian energy, illustrated in the Meridian Flow Wheel, which carry a behavior-inducing psychological consciousness specific to each path.

Meridian Emotion	in the twelve paths of Meridian energy, illustrated in the Meridian Flow Wheel, which carry a behavior-inducing emotion specific to each path.
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Normative agent

Public goods	the consciousness and awareness of others' interests
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Sasang typology	Second dimensional shift (larger yin, lesser yin, larger yang, lesser yang)
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Self-Governance

Yin Energy	Pull energy, feminine
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Yang Energy	push energy, masculine
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First dimensional division	Classification; yin and yang
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Second dimensional division	Sasang constitution typology (larger yin, lesser yin, larger yang, lesser yang)
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Third dimensional division	Called Bagua, eight constitution typology; where a body contains a definitive quality exclusive from another body
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ABSTRACT

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Cognitive agent architectures embed social learning algorithms and normative frameworks for adopting others' influenced goals. However, there exists inefficiency in providing continuous, situational decision-making to emerge social, altruistic norms. The thesis reconstructs social-ecological learning mechanisms to functionally and efficiently internalize situational cooperation. By orienting agents to be self-aware of their three-dimensional vectors, i.e., physical, emotional and intellectual in graphical representations, this thesis hypothesizes the parsimonious, action-predictive four emotions that not only link perceptions, action, and cognition by events but also the emotional continuity functional to social-ecological rationality of agents in continuum. Twelve Meridian system is employed to conceptualize the equalizing, complementary, heuristic orientation (ECHO) model. ECHO simulates "naturalistic" cooperation to model embodied, social-ecological orientations by self-organizing emotions to emerge functional social network formations. ECHO delineates the soma links to perceptions, namely Twelve Meridian channels as "direct pipes" that initiates and conduct emotions and consciousness of three dimensional agenthood: physical, emotional, and intellectual desires. ECHO reconstructs emotions as entities to induce systemic, self-organized rule of delegation by integrating agents' percepts and actuations. By modeling constitutional emotions and consciousness of eight entities, emotions within entities as "individualized emotional processors," are constructing and integrating purposeful social, altruistic events for the efficacy of situated agents.

CHAPTER 1. INTRODUCTION

1.1 Background

By the delegation of tasks and roles in organizations, the systematic, collective adaptations through linking the minds (Carley, 1995 & 1998; Matson & DeLoach, 2003) have achieved the civilizations of today. Marvin Minsky in the *Society of Mind* (1995) presents the mindless mind as the connections of memes, the smallest chunk of knowledge, that are linked together and activated implicitly, rather than consciously (symbolically activated; instantiated). In his speculation, “[t]he secret of what anything means to us depends on how we’ve connected it to all the other things we know. That’s why it’s almost always wrong to seek the ‘real meaning’ of anything. A thing with just one meaning has scarcely any meaning at all” (Minsky, 1995, p. 64). Although it is no longer distinction between explicit and implicit knowledge (Singh, 2003), Minsky’s speculation makes the intricate synchrony of the functional brain imaginable and, perhaps in some future, computable by the paths discovered.

Neural networks theory today provides more active, domain-specific explanations of agency and connections within to build and discover knowledge by the organization of the functional brain and the conceptual mind (Calvano et al., 2005; Michell, 2006; Anderson, 2010; Lonker & Dedon, 2011). Mirror neurons, for instance, show the concurrent simulation of the functional brain that perceives the movement or emotion of others (Rizzolatti & Craighero, 2004; Rizzolatti, 2005; Oztop et al, 2006). Neural reuse theories, like simulated cognition, address the functional reuse of neural networks to perform complex cognitive behaviors to demonstrate how the brain operate cooperatively to

produce different behaviors by the sum of neural networks (Anderson, 2010). Certainly, getting away from symbolic, logic rules, connectionists' agencies can make flexible but organically meaningful links to make agencies as functional and flexible possible.

The emergence of social behaviors is replicated in population; nonetheless, social influences are not universal. Others' expectations are enforced and sanctioned to establish the orders and the efficacy of human societies but for the adaptive operations of agencies must involve self-regulation. In the 1991 article, *Intelligence Without Representations*, Brooks' asserts that "[r]epresentation is the wrong unit of abstraction in building the bulkiest parts of intelligent systems" (p.139). Brooks (1986) built mobile robots to explore their situated environments without collisions and designed purely reactive architecture by layered modules that are decomposed by activities and visible objects without keeping mindful records. His vertically layered, reactive architectures are effective at designing agents that adapt to changing environments. However, keeping the number of layers in check facilitates the coordination, otherwise, the layers are having another form of multiagent issues within agents ((Müller et al., 1995). Brooks' robots were situated in "definable activities" that can be abstracted (decomposed) as basic actions and path findings were feasible by repetitions and combinations of action units to arrive at the goal state. In practice, deterministic social environments are difficult if not unrealistic in most agent-performance environments.

Ulric Neisser shifts Skinner's behaviorism, quantifiable, objective psychology to cognitive psychology paradigm, the mind that "symbolically" represents and constructs the world: the human brains as the active information processors, which are organized in two-

way information: top-down versus bottom-up processing of the thinking box. However, Neisser (1967) in his book called *Cognitive Psychology*, addresses the criticality of “intrinsic” motivation in selecting and processing external information. He notes what a self is seeing, thinking, and feeling is predisposed by one’s tendency to have certain, subjective motives. In his words, “[d]ynamic psychology, which begins with motives rather than with sensory input... Instead of asking how a man’s actions and experiences result from what he saw, remembered, or believed, the dynamic psychologist asks how they follow from the subject’s goals, needs, or instincts” (Neisser, 1967, p. 4). As Neisser’s explanation, the duality (inside versus outside of the person) may well be the flip side of a coin and it is the same coin we are speculating as if they are separable. Like the coin, two sides of a person need to be adhered together by a seamless representation of both.

Cognitive architectures (Langley et al., 2009) are lacking in the reactivity due to the difficulties in changing the beliefs of agents locked in symbolically driven operations (Balke & Gilbert, 2014). To complement the lag in agents’ symbolic beliefs and goals, reactive-modules are layered as subsystems (Müller, 1995; Aaron et al., 2002; Audin & Orgun, 2010; Balke & Gilbert, 2014; Sun, 2015; Adam & Gaudou, 2016) and “[g]enerally speaking, in each subsystem, among the two ‘levels’, the ‘top level’ encodes explicit knowledge (using symbolic–localist representation) and the ‘bottom level’ encodes implicit knowledge using distributed representation” (Sun, 2015, p.193). The author delineates the processes of Connectionist Learning with Adaptive Rule Induction On-line (CLARION), a cognitive architecture that has been form-fitted to integrate with some folk psychological notions such as instinct, intuition and creativity and to drive of three phase model: “(1) the explicit phase: process given information; (2) the implicit phase: develop

intuition using implicit declarative knowledge; finally the intuition emerge into explicit processes and therefore (3) the explicit phase: verify and validate the result using explicit declarative knowledge” (Sun, 2015, p.194).

To make “meaningful; adaptive” links between two processes, the implicit and explicit, agents must purposefully construct the values of events simultaneously when they perceive and where they are situated (Smith & DeCoster, 2000; Sun, 2015; Zittoun & Gillespie, 2015). Cognitive architectures, symbolic information processing has been reputed by theories that explain implicit, embodiment of knowledge as the extension of the world within intelligent beings (Thelen et al., 2001; Barslou, 2008; Paolo et al, 2014). Demiris and Johnson (2003) presents the architecture of sensory cognition e.g., action recognition and imitation, to simulate the process of imitations through social interactions based on a ‘simulation theory of mind’ approach. The schema taken from infants’ imitations skills by the function of mirror neurons has shown robots’ increasing learnability from primitive to more complex composite motions (Demiris & Johnson, 2003). The authors’ report that the sensory cognitive architecture applied was successful, stating:

a robot to use its motor systems in a dual role, for executing actions as well as perceiving them when performed by others. This activation of the motor systems during observation is in agreement with the recent biological data on humans and monkeys... has even produced testable predictions regarding the behaviour of the mirror neurons with respect to the speed of the demonstrated actions (Demiris & Johnson, 2003, p. 240).

Furthermore, the mechanism of mirror neurons demonstrates the basis of internalization of others' movements and feelings and simulates perceptions in the brain (Oztop, 2006). Rizzolatti (2005) conceives "to recognize an action, one should activate the motor system.... A mere visual perception, without the involvement of the motor system, would only provide a description of visible aspects of the movements of the agent. It would not give, however, information on the intrinsic components of the observed action, on what means doing it, and of the links of the observed actions with other actions related to it. To put the observed action into a motor semantic network is simply necessary if one has to understand what the observed action is really about" (p. 419). For computing to recognize objects, agents must represent meanings of objects seamlessly in the loop of perceptions (sensory systems) and actuators (motor systems).

The cycle of perceptions and actions is better captured by the so-called "enactive mind" that closes the gap between symbols and meanings of the symbols represented in the mind of agents. To close the gap, instead obscuring meanings (values) in dual processing, there must be one integrating mechanism to construct meanings of dual processing to focus. According to Paolo (2014):

on value generation and question the coherence of the idea of a value system in cognitive architectures (both computationalist and embodied) and similar modular structures whose function is to generate or judge the meaning of a situation. This question allows us to highlight right from the start one of the main differences between enactive and traditional views: a grounding of notions such as values and meaning (p. 35).

Since its debut in 1956, the concept of the bounded rationality (Simon, 1956), unintentionally guided Distributed Artificial Intelligence (DAI) to implement social norms to affect individual compliance in the frame of normative multiagent systems (Vazquez-Salceda et al., 2005) thereby increasing complexity (Balke & Gilbert, 2014; Adam & Gaudou, 2016) rather than adopting simpler social-ecological rationality in making decisions. On occasions, enforcing social norms is the most effective coordinating factors for collective efficacy (Vazquez-Salceda, 2005; Lo´pez y Lo´pez, 2006; Andrighetto et al., 2010; Savarimuthu & Cranelfield, 2011). To enact more complex, predictive socialization, agent architectures further developed the mechanisms to internalize social rules and social norms; however, reasoning normative behaviors demands meta-cognitive structures that increase the computational complexity (Aaron et al., 2002; Vasconcelos, 2009; Sun, 2015) for autonomous agents to make sense of cooperation. As discussed previously, imitating and enforcing would not effectively elicit the adoptions of social norms that conflict with the self-interested goals of agents.

This complexity is the deviation from the adaptive merit of the ecological rationality following the bounded rationality of “sufficing behaviors” (Simon, 1956). Ecologically rational organisms maintain simple search rules, simple stopping rules, and simple decision rules, in which all three adhere to circumstances that take place (Gigerenzer & Goldstein, 2011). For organisms to be ecologically adaptive, it is necessary to self-regulate these simple search, stopping, and decision rules to be cooperative (Selten 1998; Gigerenzer & Goldstein, 2011). For instance, the merit of a rationally bounded infant does not waste time to be adaptive. When an infant feels hunger, one immediately seeks “social-ecological” help by crying, a spontaneous path then appears from the initiative of

the infant to connect with the external, social extension triggered by the embodied cognition of the infant; in turn the trigger elicits the embodied cognition of a person who perceives the signal of the infant in social-ecological boundary. This intrinsic drive mechanism has applied to cognitive agent architectures as a sort of algorithmic, social learning that uses affective appraisals to intervene or intercept the information flow of cognitive agents (Müller, 1995; Staller & Petta, 2001; Muramatsu & Hanoch 2005).

Simultaneously, evolving in time and space by the selective processes functional to environments, humans' learning induces almost automatic, implicit decisions. Dolan et al. (2012) proposes nine powerful contextual, implicit impacts on changing individuals' behaviors in making financial decisions, so called, MINDSPACE, mnemonic stands for Messenger, Incentives, Norms, Defaults, Salience, Priming, Affect, Commitment and Ego. For the scope of the thesis, acknowledging a MINDSPACE framework guide people's economical choices that are irrational, quick, and influenced by others' intentions. Not purposefully guided by self-interests but driven by others' influences, according to Dolan et al., what is "rational" to a person depends on situations and one's attentions to make decisions in parallel with external influences that are delivered "on-time" to a decision maker.

In social-ecological continuum human actions can be evaluated either selfish or altruistic. Within the frame of social-ecological effects over time and in space, altruistic (self-less) behaviors in multiagent cooperation acquire attentions to be applied due to unlocking social dilemma. The spectrum of social actions ranges from mostly informative as well as functionally adaptive and, not as common but surely, altruistic at times (Gintis, 2003). Altruistic behaviors are social actions at the highest level but that are not well

simulated among autonomous agents (Matarić, 1997; Lopez and Lopez et al., 2006; Sen & Airiau, 2007; Dignum & Dignum, 2009; Andrighetto et al., 2010; Savarimuthu & Cranefield, 2011). As shown, self-interests restrict altruistic behaviors when choices are given to agents (Castelfranchi et al., 2000). It is critical to note that transformation of consciousness from self-dimension to selfless-dimension to cause altruistic actions.

Gintis (2003) proposes “strong reciprocity theory” as biological and cultural replicators that are transmitted within familial, cultural groups. Gintis asserts oblique transmission, the familial, cultural transmission as two-way processes of norm internalization and institutional socialization that enable agents to be altruistic. The result showed the effect of the internalization of altruistic norms when “[a] high level of cooperation can be sustained in cultural equilibrium by the presence of a minority of agents who adopt the altruistic norms of what we call strong reciprocity: cooperating unconditionally and punishing defectors at a personal cost, the remaining agent being self-interested” (Gintis, 2003, p. 159). Noted in Gintis’ study, the assumption of self-interested agencies is exclusive of the altruistic group when a culture with “the strong reciprocity factor” intersects with a culture with the self-interest. Internalization provides the explanation of prosociality, where an individual adopts others’ influenced goals. The self-less dimension must be provided to induce altruistic behaviors, Gintis explains the self-less dimension as an evolutionary dimension that the effect of self-interests is no longer proximate regarding external but “distally” internal.

Gintis (2003) asserts the pro-sociality as the function evolutions of human species more salient in some cultures through familial transmission in those cultures. At time of disparity ordinary people, rare but ubiquitous in every culture, become heroes and heroines

to save others' lives by sacrificing theirs. In those transformable situations, the autonomous, rational choices must be overwritten by social-ecological dependences to rationalize prosocial actions functional to the situations. These prosocial behaviors are in time to be shown as somewhat, biological markers, e.g., the neurobiological evolution, socialization and internalization can all together explain prosocial actions (Gintis, 2003; Gardner, 2008) and refer to neural reuse in the social and emotional brain (Anderson, 2010). However, due to the lack of multi-factorial theories that explain the ubiquitous, social-ecological dependences in multiagent systems, agents' prosocial but rational choices become "irrational" to achieve the systems' goals. The efforts of developing social intelligence in autonomous agents had continued to apply multi-disciplinary theories to make sense of fast learnability most of us thrive with and willingness to give for others. Regardless, the lack of comprehensive, symbiotic explanations of social-ecological dependences has kept agent modelers "steady-still" in the complexity rather than the simplicity of the ecological rationality that facilitates fast, functional decisions to act altruistic and cooperative.

The role of emotions has been identified in agent architectures to trigger motives for fast, adaptive actions (Cañamero, 1997; Michaud, 2002; Lempert & Phelps, 2013) that bring ecologically rational outcomes for agents (Simon, 1956; Muramatsu & Hanoch, 2005; Gigerenzer & Goldstein, 2011; Hawes, 2011). As a reactive process to fit agents in the structure of their environments, computing emotions enable cognitive agent architectures to integrate more of embodied elements and to readily link their memory systems and information processing (Michaud et al., 2001; Michaud, 2002; Muramatsu & Hanoch, 2005; Lempert & Phelps, 2013; Adam & Gaudou, 2016). The study of Adam & Gaudou (2016) summarize the usability of Belief-Desire-Intension (BDI) architectures in social

simulations to predict the patterns of micro-macro interactions. In conjunction with beliefs, desires, and intentions, the properties of emotions are integrated as appraisals or coping mechanisms in various realistic simulation scenarios, e.g., evacuation, believable agent interaction, military training, individualized decision-making, learning social norms, and so forth. The authors advocate that BDI agents are suitable in social simulations due to subjective architectures model human erroneous behaviors; however, they criticize that it is almost impossible for BDI agents to subjectively comply with critically important social norms (Adam and Gaudou, 2016). The unambiguity is unattainable in BDI architectures in communication due to the fuzzy, subjective logical errors that they are bound to make based on agents' subjective belief systems.

According to Bandura (1994), humans' autonomy derives from perceived self-efficacy by experiencing their continued successes and/or observing others' successes. A form of social learning theories that advocates the self, who perceives one's control over the environments in producing one's intended successful outcomes rather than the control of the environments (Eccles & Wigfield, 2002). Additionally, Bandura delineates the formation of the self-regulated experiences of infants, which produces physiologically and psychologically sufficing behaviors. Bandura's explanations of adaptive actions are originated from the self who experiences external successes by receiving what she wants i.e., intrinsic drives of a distinct self. From Bandura's social learning theory, when "a distinct self" is associated with successful events and good internal feelings, the self-develops the efficacy within. Although it is one of the most popular theories of psychology, the theory gets criticized in the account for an unclear procedural distinction between the internal states and the externalities of the behaviors of the self. It seems that the distinction

should lie between the self and the external world; however, he asserts as the distinction from the others. Deci and Ryan articulate the inconsistency of Bandura's self-efficacy theory and criticizes that Bandura has confounded the innate nature of seeking competency and autonomy within the self.

Self-efficacy theory evolved from incentive theories—that is, theories that focused on people's striving to attain desired reinforcements....Because the theory does not distinguish between autonomous and controlled behaviors, it maintains, at least implicitly, that people who are pawns to reward contingencies or to other controlling events are agentic so long as they feel able to carry out the activities they feel coerced or seduced into doing. It is here that inconsistencies in the apparent metatheory of self-efficacy become apparent because without acknowledging intrinsic activity and an inherent growth tendency, self-efficacy theory is not equipped to deal with a more complex and meaningful conceptualization of agency (Deci & Ryan, 2000, p. 256-257).

Deci & Ryan oppose Bandura's self-efficacy theory. Their theory is drawn from experiences and observations in shifting focus to internal states of an ecologically rational infant, who triggers external events based on triggered internal states. Even so, Bandura's meta-theory accounts for acknowledging physical and psychological sensations within the person. These sensations represent the feelings of self-efficacy in external reinforcements. These external symbols and events are reconstructed by the internal experiences of a distinct self, which mostly grounded with subjective feelings of success.

In contrast to instrumental motives (incentives) on actions, Abraham Maslow (1943) postulates humans' motivations as "innate" and states that individuals' actions to satisfy basic needs of i.e., survival, security, belongingness, and self-esteem and innate needs are drives in developing selfhood that chooses the patterns of behaviors. These basic needs have, to attain self-preservation and interests, the precedence over higher growth needs, the self-actualization (Maslow 1943). Although Maslow's self-actualization theory has brought the attention of wellness factor to psychology, operationalizing the constructs of five intrinsic needs, the difficulties exist in shifting in the hierarchy from four deficit needs to self-actualization growth need at the top. The difficulties reside in the qualitative, categorical difference from the lower, deficit needs to the top. The ascending mechanisms need transformational factors for jumping up to the higher level, which transformation would not occur universally in humans. It seems that evolution of needs are more in between rather than within; hence, the hierarchical representation of needs are insufficient to simulate interactions of those needs in multi-agent systems at cross-sectional encounters unless the simulation require the time to mature to show individualization.

In addition to two-facet theory of intrinsic motivations of Maslow, Reiss (2004) articulates the multifaceted nature of sixteen intrinsic needs that are ends of actions, not means to ends. However, Reiss (2004) points out precisely the shortcomings of Maslow's hierarchical representations of intrinsic motivations:

[e]nds are indicated when a person engages in a behavior for no apparent reason other than that is what the person desires to do. An analysis of a person's behavior may identify a series of instrumental acts followed by one or more end goals that complete the 'behavior chain'....Multifaceted

theory holds that the various end goals [sixteen intrinsic needs: Power, Curiosity, Independence, Status, Social contact, Vengeance, Honor, Idealism, Physical exercise, Romance, Family, Order, Eating, Acceptance, Tranquility, Saving] are largely unrelated to each other, perhaps to the point where they are genetically distinct sources of motivation with different evolutionary histories (p. 179-180).

Reiss argues the distinctions between instrumental motives and intrinsic needs are grayer than many explains in duality; furthermore, the reduction of intrinsic motives into categories or hierarchy remain in the need of validating by substantial, empirical data.

By self-determination theory, more parsimonious, intrinsic needs, Deci and Ryan (2000) offer intrinsic motives as:

integration of regulations and values in the self...[o]ur concept of self, because its organismic basis, begins with intrinsic activity and the organismic integration process—that is, with the innate tendencies of human beings to engage in interesting activities and to elaborate and refine their inner representation of themselves and their world. The activity and integrative tendency move the organism toward a more unified set of cognitive, affective, and behavioral processes and structures (p.248).

Whether intrinsic needs are unitary or multifaceted, theories of intrinsic motives explain the quality of intrinsic “ends” that move the person to act and therefore starts the

cyclical, reciprocal internalization processes (Zittoun & Gillespie, 2015). Because if a person is depending on instrumental motives to start an action, there must be external incentives to bring about an initial action; hence normative frameworks provide the difficulties in internalization of altruistic norms (Castelfranchi et al., 2000; Andrighetto et al., 2010). However, intrinsic motivations are more likely eliciting prosocial actions if a person internalizes altruistic norms. As discussed, altruism can proximately be explained by the internalization of the instrumentality of altruism in social norms (Gintis, 2003; Zittoun & Gillespie, 2015).

Based on the comprehensive evaluations of cognitive architectures, Langley et al. (2009) states that “[a]lthough many architectures interface with complex environments, they rarely confront the interactions between body and mind that arise with a real embodiment. For instance, we should examine the manner in which physical embodiment impacts thinking and consider the origin of agents’ primary goals in terms of internal drives. [Moreover] [e]motions play a central role in human behavior, yet few systems offer any account of their purposes or mechanisms. We need new architectures that exhibit emotion in ways that link directly to other cognitive processes and that modulate intelligent behavior.” (p.16).

The embodiment of cognition comes from anchoring perceptions, which are dynamically linking with cognition and actions (Thelen et al., 2001; Paolo et al., 2014) “where each system is capable of residing in one of the infinitely many continuous states. Over learning, states of these systems become coupled to reflect patterns of interaction with each other and with the environment effective in achieving goals” (Barsalou, 2008, p. 621-

622). Perceptions link proximate actions and cognition, the internal state of the mind; nonetheless, emotions “dynamically” link perceptions, cognition and actions meaning produces the changes; hence emotions change systems’ behaviors in both perceptions and cognition to immediate actions accordingly (Muramatsu & Hanoch, 2005; Naqvi et al., 2006; Salichs & Malfaz, 2012). This thesis, upon the review of agent architectures in multiagent systems, introduces a novel representation of embodied cognition, which quickly orients agents to equalize in relativity and finds complementary, social-ecological rational choices.

After almost three decades since Minsky’s rather convoluted connectionism by emerging implicit, subjective paths to causal knowledge in the brain, the progress in understanding human’s cognition is well articulated by Andy Clark (2013) in the article, *Whatever next? Predictive brains, situated agents, and the future of cognitive science*:

Thus constructed, an action-oriented predictive processing framework is not so much revolutionary as it is reassuringly integrative. Its greatest value lies in suggesting a set of deep unifying principles for understanding multiple aspects of neural function and organization. It does this by describing an architecture capable of combining high-level knowledge and low-level (sensory) information in ways that systematically deal with uncertainty, ambiguity, and noise. In so doing it reveals perception, action, learning, and attention as different but complementary means to the reduction of (potentially affect-laden and goal-reflecting) prediction error in our exchanges with the world. It also, and simultaneously, displays human learning as sensitively responsive to the deep statistical structures

present in both our natural and human-built environments. Thus understood, action-oriented predictive processing leaves much unspecified, including (1) the initial variety of neural and bodily structures (and perhaps internal representational forms) mandated by our unique evolutionary trajectory, and (2) the acquired variety of “virtual” neural structures and representational forms installed by our massive immersion in “designer environments” during learning and development. To fill in these details requires, or so I have argued, a deep (but satisfyingly natural) engagement with evolutionary, embodied, and situated approaches. Within that context, seeing how perception, action, learning and attention might all be constructed out of the same base materials (prediction and prediction error minimization) is powerful and illuminating.

(Clark, 2013, p.20).

For instance, humans’ physiological reactivity to their environments is almost automatic, implicit emergence, e.g., systemic inflammation processes (Hurst et al., 2001; Calvano et al., 2005; Lonkar & Dedon, 2011). Even when humans make economical “supposedly rational” choices, most of us are not computing explicit, rational choices (Dolan et al., 2012). Adaptability requires a component of learning “on demand” and making quick, appropriate decisions based on environmental changes. Understanding the on-time and social-ecological factor, applying social intelligence (Steels, 1995; Wooldridge, 1995) only makes sense with embodiment of cognition that connects the concept of ecological rationality (Simon, 1956; Boyd & Richerson 2001; Gigerenger &

Goldstein, 2011) and its effects on human development (Bronfenbrenner, 1994). The effects of the social-ecological dependences are intrinsic and develop the patterns and traits of social behaviors within agents, who are simultaneously, evolving in time and space by the selective processes (Nolfi, 1994; Gintis, 2003; Gardner, 2008).

1.2 Scope

This thesis takes on speculative, Eastern philosophical approaches to arrive at the model, named ECHO, of which mnemonic stands for Equalizing, Complementary, and Heuristic Orientation. The ECHO model proposes the navigational functions upon agents' self-organized orientation to make sense of the effects of social-ecological dependences to induce altruistic, social behaviors. The scope encompasses the extensive analysis of social norms and social learning theories applied in modeling of normative, multiagent architectures thus far to conceptualize ECHO based on Eastern alternative medicine theories consisting of twelve Meridian system. At a validation stage of the ECHO model, the proof of the concept is discussed in a cooperative scenario of situated agents to emerge self-organized, social; altruistic norms and roles.

1.3 Research Question

The paths to infer knowledge from perceptions, cognition and actions can be as many as the number of people and organisms on earth or as neat as the minimal cognitive procedural objects that are defined by the higher-level analysis of cognitive functionalism. In the relation between the mind of the person and the world outside the person, the mind produces reality with subjective-laden errors and environmental noises (Clark, 2013). No

matter how many processes there are to infer knowledge and to produce actions, the end goal of defining processes is to understand organisms' adaptability to incorporate the adaptability of the machines in DAI.

Numerous social learning theories and cognitive theories exist to make intelligent agents as adaptive as possible. However, gap exists in explaining situated, social-ecological dependences due to the seamless internalization of these connectivity. To make agents to be socially and ecologically intelligent, this thesis hypothesizes the parsimonious, action-predictive emotions that not only procedurally link perceptions and actions but also continuously predispose perceptions and actions functional to social-ecological rationality. This thesis follows the theory of the twelve Meridian system and put emotions into actions to make-up entities that enable the sociality of intelligent agents that self-organize three-dimensional social networks.

1.4 Significance

By nature, organisms adapt on demand. Herbert Simon coined the term, the bounded rationality and he asserts succinctly that “[e]vidently organisms adapt well enough to ‘satisfice’; they do not, in general, ‘optimize’.” (Simon, 1956). In the article, Simon concludes that organisms' behaviors were identical and repeated to serve their multiple needs. Calculating the most rational path is not only computationally wasteful but also unattainable due to organisms' structural subordination to the natural laws of space and time. Organisms are bounded to ecological structures to emerge satisfactory thoughts and actions. ECHO proposes a generalized mechanism to emerge these sufficing behaviors of situated agents that are cooperative, namely altruistic norms.

Autonomous agents in isolation are unlikely since systems are connected to the preexisting systems without exceptions; therefore, autonomy calls for self-organization of the external world (Steels, 1995) by “a constituent, integral part” of organisms to emerge knowledge and adaptive actions. The reactive, social learning is purposive but ad hoc. Organisms continue to orient themselves according to social-environmental changes and to make decisions interactive to the situations through the constituent part. These emergent reactions are best operable within the contexts of social, ecological interactions and bring our personal goals closer than we ever planned or imagined.

The studies of social norms and social learning theories are applied in modeling externalities (e.g., rewards and sanctions of the society) and internalization of the external world of agents to enable the ad-hoc learning to be cooperative. In building cooperative society, emotions had been identified as the constituent part to link perceptions, cognition, and actions of autonomous agents. Emotions “as a process” thus far had facilitated autonomous agents to prioritize activities that are critical to avoid damaging either structural and social collisions to intercept deliberating decision processes in cognitive architectures. However, the procedural emotional intervention fell short in explaining persistent, predictable individualized behaviors. Through emotions, ECHO models the bounded rational choices of agents being tangent with social-ecological orientation. In ECHO, emotions moderate the proximate causes to perceive and act upon what they perceive. Moreover, feeling predisposed emotions is the constituent part of ECHO to propose the psychological tenacity to cause 3D social-ecological interactions that are cooperative.

For an autonomous agent to choose others-influenced goals, agents must acknowledge inherent social or ecological, resource-bound, dependences as a unit in a system (Castelfranchi 1992; Opp, 2001; Castelfranchi & Paglieri, 2007). The underlying mechanism, defined by Twelve Meridian system, connects and orients agents within their social-ecological environments. ECHO introduces agents' orientation in respect to their social-ecological structures as the extensions of the embodied cognition, drives and entities to cause adaptive, altruistic actions. This thesis claims the efficiency of a comprehensive, naturalistic mechanism of Twelve Meridian system that generalizes the paths of agents' altruistic actions. The identified implicit representations of Twelve Meridian system are three-dimensional desires of emotions and consciousness. The percept-actuator loop of situated agents starts from these 3D representations interacting with their social-ecological environments. The simple orientation rules and 3D heuristics select how to become cooperative.

1.5 Statement of Purpose

“Becoming” altruistic is pivotal to enable autonomous agents to be cooperative. This thesis argues the insufficiency of disjoint multidisciplinary theories in modeling a comprehensive mechanism that guides the effective, efficient paths to be prosocial for situated, autonomous agents. This thesis augments the implicit, automatic processes of the sociality that is critical to implement the accumulated evolutionary, adaptive knowledge of organisms (Gintis, 2003) by the seamless synchronization of parts (entities) that belong to the whole (social-ecological environments). ECHO assesses the reciprocal, cyclical (seamless) synchronization between entities and social-ecological environments with the

rule of yin and yang equilibrium. Twelve Meridian system processes three-dimensional desires: physical, emotional and intellectual to gauge altruistic actions based on the internal states of these desires.

1.6 Delimitations

The thesis follows the definition of the bounded rationality extended to ecological rationality (Gigerenzer & Goldstein, 2011). Many scholarly efforts are dedicated to the concept to advocate and provide clearer explanations and applications of the terminology. The bounded rationality is neither irrational nor optimized under constraints (Russell & Norvig, 1995). Additionally, it must contain three criteria: simple search rules, simple stopping rules, and simple decision rules (Gigerenzer & Goldstein, 2011). Although there are some simple rules existed in the reactive layers of architectures, the cognitive agent architectures deviate from the bounded rationality concept due to their complexity in changing their mental states from perceptions to cognition.

1.7 Assumptions

The Meridian system theory (Kim, 1965; Kim 1989; Soh, 2009; Longhurst, 2010; Lei et al. 2014) and its applications (e.g., Ho & Knight, 1998; Pan & Zhou, 2005; Ge et al., 2015) are a deductive inference that is established in the Eastern, alternative medicine. There is countless, clinical evidence of yin/yang imbalances corrected by systemic, energetic rehabilitation of the Meridian paths by KTM (Kim et al., 2005; Leem & Park, 2007; Shim et al., 2008; Ahn et al., 2009; Jung & Ahn, 2012; Park & Kim, 2015) and by TCM (Chang, 2012; Dashtdar et al., 2016; Fung & Kong, 2018). The medicinal practice

of the Meridian system theory has guided the holistic healing and insurmountable clinical evidence that validates the effectiveness of the theory (Chapple, 2013; Zhang et al., 2015; Dashtdar et al., 2016) and well-established in the practice of the Eastern medicine (Ulett et al., 1998; Kim et al., 2005; Leem & Park, 2007; Park & Kim, 2015). The clinical effectiveness (e.g., Park & Kim, 2015) of the Meridian system is substantiated in the article by Chang (2012):

the widespread use of acupuncture in the East and West has helped millions of patients worldwide. This is perhaps one of the main reasons that in 1980, the World Health Organization (WHO) recommended acupuncture as an effective alternative therapy for 43 different disorders (p. 507).

However, in this thesis, evidential substantiations of the effects are not the focus. The purpose of the study is to connect social, evolutionary theories applied in AI complex systems and to make the practical, causal use of emotions in entities that dynamically connect perceptions and actions. The thesis assumes the validity of existing agent architectures to suggest the added value of twelve Meridian system for a more comprehensive understanding of human adaptability. The literature review on existing cognitive architectures and inherent complexity issues will shed critical insights on conceptualizing ECHO based on the application of Meridian system theory for making agents' on-demand coordination and cooperation as effective and efficient as possible.

1.8 Limitations

Due to the meta-analysis (the reports about the reports), the sampling of the reported data rearing the significant results can overrate the significance of the hypotheses of the studies by leaving out the non-significant data. Regardless, some cross-validating results are shown. The variances between significant dependent variables in the data add more value than their removal in this thesis. Additionally, the current study accepted the face value of reported simulation samples since the sampling process was non-biased. Meaning that most simulations used computerized, repeated, and random testing in using proper experimental design methodology.

1.9 Summary

The studies of social norms and social learning theories are applied in modeling externalities (e.g., rewards and sanctions of the society) and internalization to make artificial intelligent systems as cooperative as possible. Autonomous agents in isolation are unlikely since systems are connected to the preexisting systems without exceptions; therefore, autonomy calls for self-organization of the external world (Steels, 1995) by “a constituent, integral part” that are connected to the body of organisms. Humans continue to learn to react to social-environmental changes and to make decisions “functional” to the situations that arise by detecting the world by the constituent part within the body. To make agents’ social actions being tangent with social-ecological rationality, the theories of embodied cognition asserts emotions that connect perceptions and actions, either cognitively. For situated agents, this thesis model ECHO that moderates the proximate causes to be altruistic on-demand. Often than not, these opportunistic, emotional reactions

operate within the context of social, ecological interactions bring our personal goals closer than we ever planned or imagined. Emotions in ECHO are not procedural but purposive to guide agents to become altruistic within their social-ecological environments. Keeping the connection with the social-ecological changes is what make us best in adopting systems' goals. This thesis delineates the social-ecological model, ECHO that defines the constituent part that governs the changes and relativity of Twelve Meridian system to be refined as three-dimensional desires of agents.

CHAPTER 2. LITERATURE REVIEW

Ecologically rational organisms maintain simple search rules, simple stopping rules, and simple decision rules; all three adhere to circumstances that take place (Selten, 1998; Gigerenzer & Goldstein, 2011). However, adopting one another's goals, on-demand is somewhat delayed in autonomous agents' local mental representations that are focused on self-interests. This thesis revisits the concept of social-ecological rational decisions that can be made by information collected from self-organized social links as the mechanism of "social norms." The adaptive inferences quickly generated from time-bounded, bidirectional influences between the organism and the environment (Gigerenzer & Goldstein, 2011). In section 2.1, this thesis reexamines one of the current social solutions for cognitive agents to emerge social normative expectations in multiagent systems to help one another comply with social norms that are beneficial for the collective. In contrast to normative, social externalities to be cooperative, in section 2.2, this thesis reviews the internalization influence agents' decisions on altruistic behaviors that are pivotal social actions that have built human civilization to where we are. The review of current cognitive architectures and normative, social behaviors proceed modeling ECHO. In section 2.3, the theoretical foundation of the ECHO model is explained extensively.

2.1 Externalities: Normative Frameworks

This section reviews the instrumentality of social norms to influence autonomous agents, attained by the externality (Bandura, 1994; Opp, 2001). After all, the debate becomes meaningless if there is any "accepted; normative" mechanism to influence one another for each other's ends. To bring about the instrumentality to collective/social

interactions, the others' influence argument in normative agent systems to ensure "public-goods [e.g., driving the right-side of the road] and private goods [e.g., no-smoking rules in the presence of non-smokers]" to emerge social norms (Opp, 2001, p. 116).

The rational, individual choice on actions is given by the instrumentality at the societal level, preserving and perceiving others' agencies as individuals (including the self) who are potential beneficiaries of emerging norms. Social norms are heavily researched in multiagent systems due to the utilitarian formality of prescribing actions to regulate agents' disruptive behaviors or to foster cooperative behaviors (Castelfranchi et al., 2000; Lopez y Lopez et al., 2006; Vazquez-Salceda et al., 2005; Dignum & Dignum, 2009). Boella & Torre explains the normative multiagent systems as not only "the logic of obligations and permissions [but also] beyond logical relations among obligations and permissions... relating regulative norms to constitutive norms, explaining the evolution of normative systems, and much more" (Boella & Torre, 2004, p. 5). The critical problem in building normative agent systems is to define and categorize "beyond" logical relations of obligations and permissions in distributed systems that share less than desirable to communicate with one another. In distributed situations, having norms denoted and letting the denotation of norms known to individuals are ornery, tedious tasks that are stand-alone research area (Wooldridge & Jennings, 1995; Sycara, 1998).

No matter how normative multiagent systems are represented, doubtlessly, the framework of a normative agent enhances the sociality of an autonomous agent. Otherwise, the rational choice fails to develop social behaviors. As shown in the social simulation of robots, Matarić (1997) implemented social learning algorithms to delineate the emergence

of social rules in low-level, reactive robots. The robots were programmed with a set of basic, mobile functions and primitive, broadcasting functions. As the author noted, lacking the representations of the other robots as collaborators, the robots competed with one another; hence, the result showed the hardship in bringing the collective success at individual costs. Additionally, Sen and Airiau (2007) simulated social learning to observe the emergence of social norms through multiple, heterogeneous, direct social interactions (enforcing) rather than imitating by social observation (modeling). The authors found the direct, repeated, personal interactions successfully facilitated the spreading of social norms (Sen & Airiau, 2007).

The result of Sen and Airiau's study differs from Matarić's results. The repeated enforcement from others could develop the expected behaviors through interaction. Sen and Airiau optimistically solved "social dilemmas" by using social reinforcement. Social reinforcement induced social behaviors among agents with "normative" expectations and similarly imitated self-protective behaviors. However, social interactions alone cannot elicit altruistic behaviors, to the extent of truly "social" behaviors. Without overriding the autonomy of agents to follow social norms, the framework of expected behaviors brings out temporary social learning that is hardly transferable without norm salience and social reinforcement (Opp, 2001). Again, in distributed systems, maintaining the continuity of norm salience and social reinforcement become unattainable at some if not most of the time (Savarimuthu & Cranefield, 2011).

Additionally, Castelfranchi et al. (2000) investigated the comparability in adopting others' goals as a deliberate agent. This experiment can identify social norms and decide

whether to follow them or not. When choices were given to agents, the authors found resistance in following altruistic norms (Castelfranchi et al., 2000). A normative framework of a society cannot induce altruistic behaviors sufficiently. In terms of the instrumentality proposition, public goods should emerge altruistic norms at bottom-up only when appropriate norm salience and externalities exist to sanction or reward individuals (Opp, 2001).

Like Castelfranchi et al., Dignum & Dignum (2009) proposed a normative agent framework for deliberate reasoning about what norms to follow or not. This reasoning is determined by observing the rewards that others comply with and the sanctions that occur when others violate. The authors implemented a normative framework, called OperA, to represent social norms and organizational structures to existing cognitive agent architecture. This belief-desire-intention (BDI) is moderated by personality traits and cultural influences (Dignum & Dignum, 2009). The result showed, with the normative salience, i.e., social rewards and sanctions, that the emergence of norms that brought behavioral changes to the collective (Dignum & Dignum, 2009). Both studies demonstrated the difficulties of conversing agents' altruistic initiatives unless there are significant social sanctions and pressures for agents to feel obligated to follow altruistic norms. Under the instrumentality of social norms, having violations as often as agents' making self-interested decisions would defeat the purpose of implementing normative platforms that exist fundamentally for public goods (altruism).

Implementing a more effective and altruistic normative agent framework, Lopez y Lopez et al. (2006) identified three characteristics of normative agent systems, in-group

membership, social pressure, and the dynamic nature of social norms. Upon developing the normative framework with three factors, the authors pointed out the necessity of formulating generalized norm model to be applied with “autonomous normative reasoning” for agents to deliberate their compliance (Lopez y Lopez et al., 2006). In sum, the normative agents must acknowledge social norms that exist to be adopted for coordinating or cooperating with multiagent systems, where individuals agree on the instrumentality of social norms and thereby emerging the norms of concern. However, the autonomous normative reasoning is insufficient in producing altruistic social behaviors at run-time unless they can reason the self-interests.

To observe the emergence of social norms, normative frameworks discussed thus far implemented “reasoning about social norms” and spreading social norms by the rate of social, individual, micro-interactions as agents are encountering with norms. In contrast to slower individual interactions, Savarimuthu et al. (2008) simulated rapid and complete social norm spreading through a proposed leadership framework. The framework was tested on fully connected, random, and scale-free social networks where an innovative role model propagates norms. The results showed that “the complete norm emergence” exists in all social network topology. However, scale-free social network results reflected fast and complete norm compliance “because, in the real world, people are related to each other through the social groups that they are in, such as the work group and the church group” to share information (Savarimuthu et al., 2008, p. 11).

The norm emergence by leadership demonstrates a feasible mechanism to generate speedy and collective coordination and cooperation. It is truly altruistic and transformative

in MAS. However, identifying a leader worth following in social networks can be tricky and hard to be implemented while agents are working with unknowns. As identified, in-group membership and social pressure in cohesive groups (Lopez and Lopez et al., 2006) are necessary conditions for leadership modeling of social norms to work as well as the result shown (Savarimuthu et al., 2008). Moreover, validating leadership in MAS in the form of reputation management can be contaminated by biased reports and followers (Yu & Singh, 2002; Jøsang et al., 2007; Bobadilla et al., 2013).

Savarimuthu & Cranefield (2011) surveyed to oversee the life cycle of norms: creation by leadership (another example of the leadership to propagate social norms), identification by members, propagation (spreading and enforcing), and emergence. To provide a more comprehensive perspective on increasing the instrumentality of social norms, the authors identified necessary conditions: norm sanction emotions (e.g., embarrassment, guilt, etc.), norm emergence by leadership and the cultural, evolutionary influences, and social learning such as imitation (Savarimuthu & cranfield, 2011).

Based on the instrumentality of social norms, it makes sense to formalize normative expectations and to enforce sanctions/rewards in accordance with agents' compliance. In addition to formalizing "declarative" social norms using logical symbolism in most normative multiagent systems given autonomous normative reasoning (Lopez and Lopez et al., 2006; Savarimuthu & Cranefield, 2011). Vazquez-Salceda et al. (2005) conceptualized communicative protocols to enforce relevant norms in operational situations. The authors proposed a framework that facilitates the detection and enforcement of social norms that are properly issued and relevant in time (Vazquez-

Salceda et al., 2005). The study offered “mechanisms (blacklists, action-alarms, clock-triggers, authorization) to simplify norm enforcement on multiagent platforms” (Vazquez-Salceda et al., 2005, Conclusion). Vasconcelos et al. (2009) also addressed the management of norms relevant to agents’ situations and the mechanisms to detect appropriate norms and specify the adoption and removal of permissions, obligations, and prohibitions in societies of agents.

In sum, the instrumentality of social norms and the externalities, i.e., social rewards and sanctions are not necessarily eliciting social behaviors to foster the coordination and cooperation in multiagent systems. Based on the meta-analysis, both explicit and implicit methods are used to represent norms to induce social behaviors between agents. Deontic declarative norms exist in the society of agents and the paths of the suggested emergence of norms are more implicit represented in a way of social learning by models, e.g., others or leaders. The speedy and complete social norms emerge through the leadership (Savarimuthu et al., 2008) when tested in the implicit representation of norms by social networks and links, which again shows the effect of implicit representation at work with an explicit declaration of norms. To explain the causality of social actions,

[t]o some extent, the selection of the norm to which one subscribes can also be explained by self-interest. Even if the belief in the norm is sincere, the choice of one norm among the many that could be relevant may be an unconscious act dictated by self-interest [o]r one might follow the norm out of fear of the sanctions that would be triggered by the violation. I do not believe that self-interest provides the full

explanation for adherence to norms. There must be some further explanation, X, of why norms exist (Elster, 1989, p.112).

For self-interested agents, declaring normative expectations in MAS is necessary but insufficient. However, communicating declared norms at run-time is still an unresolved issue. The process of resolving goal conflicts overlooks the simplicity of simulated adaptable behaviors. Moreover, the reasoning mechanisms that normative platforms use to negotiate the self-interest and instrumentality of social norms do not sufficiently elicit pro-social behaviors. For effective, individual compliance, Andrighetto et al. (2010) tested the normative internalization processes with an EMIL-A agent, a BDI agent with the representations of the normative beliefs about the norms, corresponding sanctions, and utility maximization of self-interested goals. The result showed “internalization is a good predictor of compliance and second order cooperation... [but] internalization takes long, and it is not necessarily successful: self-training may be too hard [in the absence of normative salience]” (Andrighetto et al., 2010, p. 338). In terms of pro-social behaviors, the following arguments provide causal links to resolve the social dilemma (Elster, 1989).

2.2 Internalization: Bidirectional, Developmental Cycling

In distributed environments to avoid the loss of “social” collisions, agent modeling had loaded cognitive complexity to rationalize social norms with self-interests. However, reasoning about social norms in respect to self-interests limits agents’ social actions within the protection of self-interests (Lopez and Lopez et al., 2006; Dignum & Dignum, 2009; Savarimuthu & Cranelfield, 2011). Unless agents acknowledge apparent social-

dependence (Castelfranchi et al., 1992; Wooldridge & Jennings, 1995) and the loss of social asset, the processes of reasoning about social norms fell short in a way that a society could not emerge social norms above self-protecting social behaviors for its efficacy. In this subsection, the thesis discusses how internalization is used to bring out prosocial-adaptability of agents in social-ecological frames. The persons and the environments (including others) are simultaneously evolving in time by selective, automatic, and implicit processes, of which the mind and the body of agents are constructing the world around as much as the world is reconstructing the persons' environments.

Castelfranchi and Paglieri (2007) denote that cognitive functionalism is that “the significant and heuristic categories of mental representations (e.g. beliefs and goals) are defined by their functions, rather than by their format, content, or other intrinsic features” (p. 239). Additionally, the Stanford Encyclopedia of Philosophy defines functionalism as “the doctrine that what makes something a mental state of a particular type does not depend on its internal constitution, but rather on the way it functions, or the role it plays, in the system of which it is a part”

Thus, beliefs and goals are the core concepts and operations of cognitive functionalism. The adaptability of these beliefs and goals are most debated in terms of what constitute to change agents' states to represent their environments and how often should agents' states to be updated corresponding to situations (Castelfranchi & Paglieri, 2007; Balke & Gilbert, 2014). In distributed environments to avoid the loss of “social” collisions, agent modeling had loaded cognitive complexity to rationalize social norms

autonomously. The autonomy of agencies means that agents must change current goals depending on their self-interests and self-governance.

For instance, BDI cognitive architectures decompose agents' mental representations as "cognitive objects" into beliefs, desires, and intentions. Balke & Gilbert (2014) surveyed fourteen articles on agent decision-making architectures using reactive production rules, deliberation, and heuristics. Enhanced with social intelligence that represents social network relations and communication, the authors found a model of deliberate agents that are functionally analyzing social dynamics such as social norms and interactions (Balke & Gilbert, 2014). However, two separate information processing (global, explicit, symbolic vs. local, implicit, perceptive), mostly layered approach in those architectures lacks in the integration of these processes to reflect complex knowledge formed by interactions thereafter.

Social norms, hence the name of norms being "social," confer informal influences to change the actions of others. The focus of studying the emergence of social norms should be the rate of appropriate changes of agents that induce coordination and cooperation among social-ecological framework. The rate of adopting others' goals is depending on the recognition sensitivity toward social norms when micro-level, social interactions devised by cohesive, social networks. To oppose Gintis assertion of social norms emerged, maintained by the oblique transmission (the evolution of familial, cultural in-groups), Andrietto et al. (2010) proposed a multi-step, cognitive framework that points out the proximate effects on the internalization of social norms. The authors offer three normative deliberation steps: recognition, adoption, and decision-making to update BDI

agents' goals based on normative beliefs in respect to normative salience, externalities, e.g., rewards and sanctions and compliance costs and benefits. EMIL-I-A (EMIL Internalizer Agent) internalizes social norms represented by a normative thermometer that computes costs of complying with social norms using coefficient weights to symbolize "consistency, self-enhancing effect, urgency, calculation cost saving, norm salience" (Andrighetto, 2010, p.328).

The internalization framework proposed by Andrighetto et al. (2010) is at best maintaining emerged "salient" social norms; based on the coefficient weights to factorize internalization, the result of the proof-of-concept simulation showed EMIL-I-A agents are "better at defending the internalized norms than externally-enforced observers" (p. 337). The normative thermometer the simulation applied is worth noticing as the parsimonious representation of the normative, proximate effect of social norms on an agent; nonetheless, as discussed by the authors, EMIL-I-A fell short to show internalizing altruistic norms.

Internalization, unlike the previous discussion by cognitive functionalism, is not only the opposite process of externalization but also the "a reciprocal [bidirectional] process of construction and integration" (Zittoun & Gillespie, 2015). From the integrating and reconstructing process, social norms usually informally are initiated and converged by members of the society. By surveying fourteen intelligent agent architectures, Balke and Gilbert (2014) selected two differential dimensions, cognitive and social intelligence influencing agents' behaviors. Although different focuses and theories applied, the outcome of existing agent architecture modeling slightly differ on the flow of information that eventually connected to agents' "cognitive" box and all other factors become constraints (e.g., emotions; Michaud et al., 2001; Aaron et al., 2002; Michaud, 2002; Naqvi

et al., 2006; Audin & Orgun, 2010; Salichs & Malfaz, 2012) to intervene the flow. Some flow vertically (Müller et al., 1995) while others flow horizontally (Sun, 2005).

Cognitive functionalism controls dual information processing (Smith & DeCoster, 2000; Sun, 2015) as parallel and intervene with one another to stop or proceed agents' deliberation or reactivity (PDP and ACT-R in detail; Anderson, 2010). Because internalization flows bi-directionally, perceptions and meanings of what the person is getting from the environment must be integrated at the early construction of meanings within the person. The distinction between inside (constructing meanings) and outside (perceiving symbols) the persons become grayer at reconstruction. In the article, *Internalization: how culture becomes mind* by Tania Zittoun and Alex Gillepsie, Toomela's definition of the internalization is reiterated "[i]nternalization is a process whereby two different mechanisms of information processing, non-verbal ('sensory') thinking and conventional language, that have been differentiated from the 'natural' processes in the course of development become united within a new mental structure" (Toomela, 1996, p.286).

2.3 Meridian theory: Internalization of social, altruistic actions

Many influential theories in cognitive science make use of the idea that value or meaning is some information appraised by an internal module within an agent's cognitive architecture, whereas in an enactive perspective, meaning is inseparable from the whole of context-dependent, life-motivated, embodied activity, without being at all a hazy concept beyond the reach of scientific understanding

(Paolo, 2014, p. 35-36).

By integrating the instrumentality and intrinsic motivations, Twelve Meridian system can model the life cycle of social, altruistic norms. Delineating Twelve Meridian system, ECHO models the emergence of yin-yang relativity, four psychological tenacity (Sasang) and eight complementary entities (Bagua). When the yin-yang transforms three times (2 to the power of 3) in Twelve Meridian system, there emerge eight entities that can understand the world and orient themselves social-ecological connections. ECHO can fill the gap in “the puzzle of prosociality” (Gintis, 2003) due to being generative of an inspirational leader, an agent integrates its self-values to social norms and/or “more likely” internalizes altruistic norms within social-ecological frames due to its personal, emotional traits to become a leader.

About five thousand years ago in China, at the time of the Yellow Emperor (2711 BC – 2598 BC)'s Canon of Medicine (황제내경, 黃帝內經), Twelve Meridian system has appeared (Lei et al., 2014). Stefanov et al. (2013) states that using photon emission provides the evidence of the energy channels connecting through the Primo Vascular

System (PVS; Lee et al., 2013), biologically observed firstly by Kim Bong Han (1965), a surgeon in North Korea. The PVS sends electromagnetic signals throughout the body parallel with the Meridian system to “allows communication between living organisms and the environment...[and] is duplicated by the vascular and the nervous systems during the very early stage of body development” (Lee et al., 2013, p. 336). A similar system comparative to the PVS is discovered in Western culture and it is called connective tissue, fascia is the net-like structure that innervates compartmentalized organs and all other peripheral structures in the body to supply nutrients and eliminate wastes through the interstitial fluids (Ho & Knight, 1998; Langevin & Yandow, 2002).

By following the tradition of Korean Saam Acupuncture (KSA; Ahn et al., 2009; Jung et al., 2012; Park & Kim, 2015), this thesis employs Twelve Meridian system of KSA (Kim, 1989) to deduce the embodiment of social-ecological orientation of ECHO agents. Kim (1989) postulates Twelve Meridian system as intangible energy channels flowing throughout the body that integrate the physical, emotional and intellectual desires. To address the core concepts of social intelligence, becoming altruistic, required in situated agents, this thesis proposes Twelve Meridian channels to connect the soma links to perceptions as “direct pipes,” which initiate and conduct emotions and consciousness of three dimensional desires of humans: physical, emotional, and intellectual (Kim, 1989).

For the audience of the West, section 2.3 overviews Twelve Meridian system, one of the major philosophy of the Eastern Alternative Medicine. KSA specially understands and interprets the states of Twelve Meridian system within the body as the root of individualized constitutions to reason the causality of illness. Today’s westernized medicine understands the manifestation of the individualized traits from the differentiation

of genetic make-ups for the cure of illness; however, the generalized theory of congenial factors yet exists. With the merit of the generalizability of Twelve Meridian system to individualization, this thesis directly follows the conventions of Traditional Korean Medicine (TKM) contributing individualized medical treatments in Eastern Medicine (Kim et al., 2005; Jung & Ahn, 2012; Chae, 2015).

While symptomatic treatments prevailed in East Asia, in the mid-17th century, the manuscript of Saam acupuncture was written by a Buddhist monk, due to the hidden identity, is called to this day as Saamdoin; hence, Saam is the name of Acupuncture system (Kim, 1989; Jung et al., 2012; Park & Kim, 2015). Kim (1989) studies Saamdoin's manuscript to interpret Twelve Meridian system in both physical and metaphysical way. The interpretation of Kim is suitable to generalize social-ecological rationality of agents to be account for all three dimensions of the humanity: the physical, emotional and intellectual desires. Respectively to naturalistic rhythms, Twelve Meridian system in the body manifests the patterns of individuals' physical, emotional and intellectual desires (Kim, 1989).

In short, Twelve Meridian system can illustrate organisms' connections to the law and order of nature mediated by Chi-flowing channels that represent physiological, psychological rhythms. The ECHO model adheres to the foundation of social-ecological rationality by implementing simple search rules, simple stopping rules, and simple decision rules (Selten, 1998; Gigerenger & Selten, 2002) based on the state of yin-yang of agents. In doing so ECHO facilitates simple quantification, and bidirectional processes by speculating on three principles of Twelve Meridian system: connectedness, relativity (equilibrium), and transformation of all things, proposed and validated by the world's

longest-standing theory: Twelve Meridian system (Canon of Medicine, 황제내경, 黃帝內經; Lei et al., 2014).

The Meridian system has been validated by using the various western visualization methods and simulation techniques, many studies showed the validity of neuroanatomical paths aligned with Meridian channels (Longhurst, 2010; Chang, 2012; Chapple, 2013; Ge et al., 2015; Fung & Kong, 2018). For instance, 361 acupuncture points and additional 34 acupuncture points in fourteen Meridian channels are individually identified with “additional specifications for point location, the stratified anatomy, motor innervation, cutaneous nerve and sensory innervation, dermatomes, Langer’s lines, and somatotopic organization in the primary sensory and motor cortices” (Chapple, 2013, p. 271-272). Additional studies (Kim, 1965; Lee et al., 2013; Soh, 2009; Stefanov et al., 2013), show the existence of the Primo Vascular System (PVS). Originally founded by Kim Bong Han (1965), a North Korean surgeon, PVS provides the actuality of the ubiquitous Chi (energy) to maintain neural signal connectivity throughout the body:

The PVS receives external and internal signals. The external signals come from the environment as electromagnetic waves. The internal signals are products of metabolic processes and arise as bioelectrical, bioluminous, and acoustical fields. These fields all bring information to the PVS concerning bioprocesses in the body. The PVS is furthermore the physical substrate for the acupuncture points and meridians and is involved in the development and the functioning of living organisms. The primordial PVS is like a matrix for the vascular and the nervous systems, which are formed around the PVS.... because it is the oldest morphological functional

system. The PVS, which until now has been a missing body system, can explain many of the mysteries of life. The physical substrate for the meridian system is the missing point that can be used to combine the knowledge of ancient Chinese medicine and that of modern science into one successful unit. (Stefanov et al., 2013, p.336).

An inspirational validation showed by Ho & Knight (1998) explains the connectedness of the Meridian system that would help model embodied cognition. Embodied cognition internalizes (integrates and constructs) dual processing: implicit and explicit. The Ho & Knight (1998) used a proton conduction method to show an anatomical and functional connection to the Meridian system. Through this method, the authors asserted organisms as the continuum of the liquid crystalline connective tissues where collagens activate and maintain the simultaneous constitution of the body and the mind (brain) consciousness (Ho & Knight, 1998). In other words, sensory and motor systems are concatenated in the Meridian system. Each meridian innervates a specific sensation and motor action to connect the body and the mind. The energy within each meridian carries each sensory and motor signal; therefore, this thesis unveils the myths of the yin-yang theory and Twelve Meridian system to simplify the concept of the embodied cognition for the cooperation of situated agents.

Shown in Figure 2.1, Twelve Meridian system is depicted with twelve animal totems at the rim of the circular chart called a Meridian Flow Wheel (MFW). The metaphysical concepts of twelve meridian energies are expressed by symbolic representations of these totems for more intuitive, simpler communication. Because twelve different energies make one, each energy is complementary for one another; hence, six meridians are paired to co-

exist and function. The center of the MFW in Figure 2.1 represents the opposite energy of the yin and yang in equilibrium, which is symbiotic relation with one another. The law of the yin and yang equilibrium (음양이론) affirms the end goal, not as means, for agents; therefore, finding a complementary set to equalize its own energy when situated. The yin-yang equilibrium maxim applies to Taijitu, Sasang, Bagua and Twelve Meridian system. The MFW represents the principle of equilibrium for all things in nature and the body as a whole.

In nature, the phenomena of the equilibrium are commonly, if not universally, observed. For examples, aloe plants have cold fluid inside their stems; this equalizes plants' energy regarding the dry, hot temperature in a desert. Mosses grow in the moist side of the tree trunks are drying agents for the trees, which equalize the moist in trees. On the hottest day where the heat rises, it rains (the water falls) to cool down. As the yin-yang energy sustains life cycles, The MFW helps identify the connections, equilibrium, and transformation between the yin and yang of all things. The layout of the diagram is complementary from one side to the opposite, e.g., the energy of a snake is complementary to the energy of a pig. The complementary is particularly important in regarding agents' representations of the world within and outside themselves because it becomes the social goal state of agents when situated. The section 2.4, this thesis extensively scrutinizes the three-dimensional transformation of Chi: Taijitu (yin-yang), Sasang and Bagua to make sense the ECHO model in respect to simulating the emergence of altruistic norms.



Figure 2.1 Meridian Flow Wheel

Note: Meridian Flow Wheel (MFW) delineates the expansion and division from the circle with the yin and yang energy balance (Kim, 1989, p. 31). MFW is the diagram of the transformation of energy from the most tenacious, unchanging yin-yang equilibrium principle depicted in the center (Taijitu) to the least tenacious that changes every two hours of the day. The cyclical rhythm can be sixty years, a year, and a day from the innermost to the outermost in the circle of MFW.

2.4 Prologue: Chi, Taijitu (yin-yang), Sasang, and Bagua

2.4.1 Chi

Ancient Eastern intellects established the systemic energy representation to denote the natural, cyclic rhythms of the body in the Meridian system (Kim, 1965; Kim 1989; Soh, 2009; Longhurst, 2010; Lei et al. 2014). Chi, energy, is a priori of all shapes of the observables are differentiated by definable characteristics of energies in the atmosphere, i.e., hot, warm, cold, wet, and dry (기, 형, 질; Kim, 1989). Hot and dry energy are defined as yang while cold and wet are as yin. In analogy, yang chi is like the bioelectrical energy that conducts organisms to grow, move, and act while yin chi to hibernate, be still, and think. Space and time “alter; change” Chi thereby factorizing four cyclical rhythms of the ecological nature of Earth, so called four seasons. As Chi constitutes the states of all tangible and intangible things in nature, Chi differentiates the states of physical, psychological characteristics of the human body (Kim, 1989). In other words, Chi is the representation of all things in nature all states in humans. In the following sections, the Chi hypothesis expands into the differentiation of Chi: Taijitu, Sasang, and Bagua to make up Twelve Meridian system shown in Figure 2.1.

2.4.2 Taijitu (yin-yang): First transformation of Chi

Taijitu defines the potentiality as well as the eventuality of the yin and yang energy equilibrium of all things (Kim, 1989); therefore, all things begin and end at Taijitu. Taijitu, the maxim of the natural law is the ultimate end goal of agents in the ECHO model. With that end, agents are always aware of their states to equalize the imbalance of the yin-yang states of themselves. The Figure 2.2 depicts a transparent, fluid-like division between the yin-yang in the Taijitu circle, where the potentiality of yin-yang is always in flux to balance

one another in the time of excess. Please note the time of excess meaning the above 50:50 ratio. The division of Taijitu is not a solid, opposing “duality” rather generative “relativity” that continuously equalizes.



Figure 2.2 Taijitu symbol.

Note: (태극도); artistic depiction of fluid-like division of the yin and yang.

As shown at the center circle of the MWF in Figure 2.1, the symbol of Taijitu illustrates the ideal state of all things: yin-yang equilibrium in the circle, meaning existing phenomenologically at the same time and space. It is equalized “only when” all things are existing at constant vacuum; however, all things exist in continuous flux. The flux of the yin-yang changes ecological, natural behaviors of all things in rhythms to call for the patterns and shapes of all things. In other words, in phenological reality, all things are either yin or yang, i.e., dark or light, which are not neutral. An entity to exist in space and time, it must alternate its state from the yin to yang and vice versa. For an example: A seed represents a perfectly balanced Taijitu (yin-yang balance) but cannot exist as a seed in

constant. When a seed becomes more yang, it sprouts by breaking the yin shell of a seed and changes its shape to be diffused, which represents its yang state in process. When a seed is planted in space and with time, Taijitu balance shifts to make changes in the shapes and energies of a seed to a sprout, leaves and branches, flowers, fruits and to seeds. The change of a seed to seeds represents the cycle of the yin-yang equilibrium in nature; it starts with a seed and it ends with seeds.

For the mind, this equilibrium stands for its stillness without any thoughts and emotions. Phenomenologically, the stillness of the mind changes to either yin or yang. For the healthy mind, the thoughts must alternate from yin to yang: the process of equalizing. So then, what is a yin or yang thought or emotion? Kim (1989) asserts yin thoughts and emotions as physical, emotional, and intellectual desires that pull things from outside to within the self. The yin is the state of earning to get. In contrast, yang thoughts and emotions are pushing and denying of physical, emotional, and intellectual desires. The yang is the state of emptying to give. The following block quotes are translated in English from Korea to honor his psychological interpretation of the yin-yang constitutions in materials parallel with non-materials.

I define ‘desires’ as yin. Because yin pulls things from outside to the self, and in the perspective of the generative circulation yin represents water. When you see something you like, the desires within yourself surface; as you see food you like (before you eat the food), you salivate, therefore, water represents yin while fire represents yang. When someone get furious, you could see fiery radiation in the eyes and redness in the face. As explained, I define anger/rage as yang, desires as yin.

(Kim, 1989, p. 24).

The generalized conditions of yin in the first dimension are: the self, females, the darkness, and in terms of the body; the left, the physical, the internals (e.g., organs), and the blood (Kim, 1989, p. 66). In contrast to the yin, the generalized conditions of yang in the first dimension are: the others, males, the lightness, and in terms of body; the right, the psychological, the externals (e.g., the eyes, the ears, the nose, and the lips), and the energy (Kim, 1989, p. 66). In short, the yin affirms desires while the yang denies desires. In ECHO, the alternation of the yin and yang is the bases of social interactions: from the yin state as get/yes to desires to the yang state as give/no to desires.

2.4.3 Sasang: Second transformation of Chi

The second transformation stands for dispositional energy imbalances; psychological traits when the yin-yang relativity continues to transform with refinement (Kim, 1989). At the second dimension, the first yin divides to the second-dimensional yin and yang; and the first yang divides to the second-dimensional yin and yang. Kim (1989) explains the order of the changes, “Taijitu divides into Yin and Yang, and then Tae-Yin, So-Yang, So-

Yin, and Tae-Yang” (Kim, 1989, p. 39). Notice the order: all things start at the yin state alternate to the yang state. Tae-Yin alternates to Tae-Yang while So-Yang alternates to So-Yin. Based on the deduction of the second transformation, in the late Josun Dynasty, Lee Jema (이제마; 1837-1900) establishes Sasang Constitutional Medicine, the world’s first individualized medicine (사상의학; Chae et al, 2003; Leem & Park, 2007; Shim et al., 2008; Kim & Pham, 2009). He breaks down the causality of illness rooted at energetic imbalances of the person: physical and psychological traits. Lee Jema describes four-constitutional topology, called Sasang which are the quadrants of crud individuation in MFW in Figure 2.1.

The Confucius scholar practicing in medicine, Lee Jema innovatively asserts Sasang to explain dispositional imbalances in the four organs as: the lungs (Tae-Yang) and the liver (Tae-Yin) as complementary and the spleen (So-Yang) and the kidney (So-Yin) as complementary (Kim, 1989; Chae et al., 2003; Kim, 2009). These four organ characteristics determine the patterns of dispositional “psychological and emotional” behaviors within individuals. Due to his scholarly backgrounds, Lee Jema explains Sasang in terms of four maxims of the Confucius: benevolence (인; 仁), righteousness (의; 義), courtesy (예; 禮), and wisdom (지; 智) (Kim, 2009; Chae, 2015). The benevolent are predisposed to feel sorrow to empathize with the poor, the weary and the troubled. The courtesy are predisposed to feel happy to make peace with others and therefore they are very polite. The righteous are predisposed to feel angry to fight with the oppressor. The wise are predisposed to feel joy to correct the wrong.

As shown Figure 2.3, in nature, four energetic changes appear as four seasons (spring, summer, autumn, and winter) and four directions (East, West, South, and North). In

vegetation, Sasang is also the changes of energy and shapes within entities; however, in humans, Sasang explains the differences between entities. Notice Sasang associated in geometrical analogy (Kim, 2009), the second transformation of all things happens where two opposite directional lines on a horizontal plane intersect with one another in one point in the middle. The four definable characteristics are not yet observable polygon (objects) by adding the verticality on a horizontal plane.

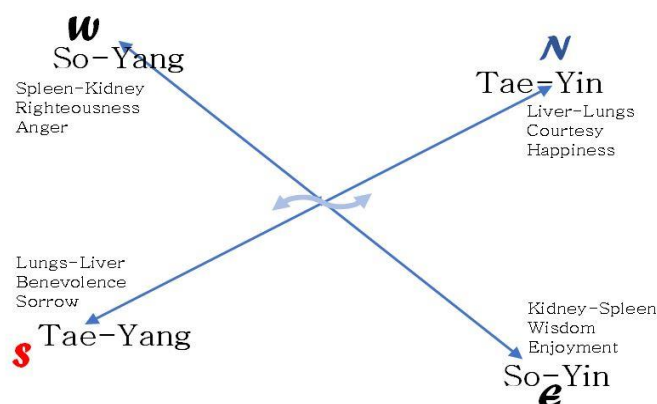


Figure 2.3 Sasang

Note: Four directions and Two Complementary Sets: Tae-Yang and Tae-Yin; and So-Yin and So-Yang. Please note the center arrow to denote the yin-yang in motion.

Lee Jema's interpretations on four typology to this day remain valid on the concepts on "psychological traits (심상; Chae et al., 2003; Shim et al., 2008; Kim, 2009; Kim & Pham, 2009; Chae, 2015). The studies of Sasang Constitution (Chae et al., 2003; Shim et al., 2008; Kim, 2009; Kim & Pham, 2009; Chae, 2015) are well established in TKM (Kim et al., 2005) to treat illness by acknowledging individual difference. The following table 2.1 is selected from Chae et al. (2003) and modified to include more details on Sasang.

The references on the modified points are included in the note section of the table. In taxonomic classification, the first division of two (yin and yang) is the uppermost row in the table to show a hierarchy of the classification.

Table 2.1 Sasang Constitution Topology

Sasang Constitution Topology (Chae et al., 2003)					
First dimension	Yang		Yin		Note & References
Second dimension	Tae-Yang	So-Yin	Tae-Yin	So-Yang	
Temperment	Sorrow	Enjoyment	* Happyness	Anger	* Modified from "gladness"
Strong Organ	Lung	Kidney	Liver	Spleen	
Weak Organ	Liver	Spleen	Lung	Kidney	
Personality Traits	Creative	Neat, mild	Gentle	Unstable	
	Positive	Negative	Commercial	Easily get board	
	Progressive	Intelligent	Eudurable	Sacrificing	
	Charismatic	Organized	Humorous	Righteous	
	Heroic	Selfish	Look foolish	Easily acceptable	
	Rash mind	Jealous	Fearful mind	Hot tempered	
		Nervous mind		Anxious mind	
Body shape	Developed nape of the neck, slender waist	Developed hip, weak chest	Thick waist, wak nape of the neck	Developed chest, small hips	
Confusionism (Superior--Inferior)	Benevolence (인)-- Courtesy (예)	Wisdom (지)-- Righteousness (의)	Courtesy (예)-- Benevolence (인)	Righteousness (의) -- Wisdom (지)	Kim (2009)
Description of Confusionism	인(仁):	지(智):	예(禮):	의(義):	Kim (2009)
	측은지심(惻隱之心):	시비지심(是非之心):	사양지심(辭讓之心):	수오지심(羞惡之心):	By Mencius (c.371–c.289 bc)
	The mind symphatizes with the poor and the trobled	The mind judges right from wrong doings	The mind yield couteously for the others	The mind get embrassed for one's unrighteousness and refrains from not being good	Translation of Mencius' maxim

As shown in Table 2.1, note the diversion at the second dimension: “Tae” denotes the doubled yin or doubled yang state while “So” denotes the yin diverting to the yang or the yang diverting to the yin. For instance, males belong to the yang domain in the first transformation of Chi, but males can also divert into two complementary characteristics: more masculine (Tae-Yang), less masculine (So-Yin). In this diversion, no changes occur

in shapes as males but changes in energy content of the same shapes. Therefore, complementary Sasang sets are: {Tae-Yang and Tae-Yin} and {So-Yang and So-Yin}.

2.4.4 Bagua: Third transformation of Chi

The third-dimensional shift is called Bagua as shown in Figure 2.4. Bagua is the simplistic, parsimonious materialization of entities with constitutional characteristics to make changes on the environments as entities (not processes). In nature and the body, Bagua symbolizes the six energetic entities between the sky and the earth. The diagram in Figure 2.4 denotes eight complementary entities by numbering and three-layered yin-yang complex symbol. Number 1 stands for south and is named as sky (☰). Number 2 stands for southeast and is named as lake (☱). Number 3 stands for east and is named as fire (☲). Number 4 stands for northeast and is named as thunder (☳). Number 5 stands for southeast and is named as wind (☴). Number 6 stands for west and is named as water (☵). Number 7 stands for northwest and is named as mountains (☶). Number 8 stands for north and is named as earth (☷).

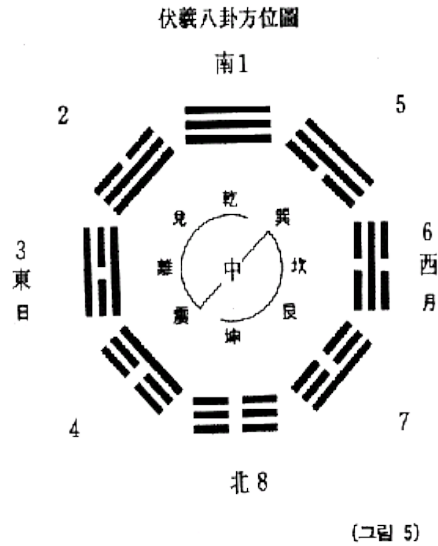


Figure 2.4 Bagua

From one of her YouTube lecture Suami Ok Yumi, states the underlying changes from the second and the third dimension. She states in translation, from Sasang to Bagua transformation, definable four energetic characteristics, Sasang are materialized in Bagua entities; hence four psychological typologies in the yin-yang eight morphological transformation. In other words, Bagua stands for eight real entities while Sasang are psychological, emotional traits in the yin-yang sets of Bagua. Bagua complementary sets are explained from Sasang and itemized in brackets {yin, yang} orderly: Tae-Yin (태음) divides to {earth (땅, ☷, 8) and mountains (산, ☶, 7)}, So-Yang (소양) divides to {water (물, ☵, 6) and wind (바람, ☳, 5)}, So-Yin (소음) divides to {thunder (번개, ☳, 4) and fire (불, ☲, 3)}, and Tae-Yang (태양) divides to {lake (못, ☱, 2) and sky (하늘, ☰, 1)}.

In 1962, Kuon Dowon has founded Eight Constitution Medicine (ECM) in Korea to individualize medicine and refine Sasang, four psychological traits into eight

individualized body types to maintain wellness by tailoring diets and activities. In his words, “[t]he constitutional theory...is splanchnological rather than morphological [relating to the form or structure of things], and it is very splanchnic [relating to the viscera or internal organs, especially those of the abdomen] interrelation theory” (Kuon, 1965, p. 152). By Sasang, four types give some morphological traits and mind associations, Dr. Kuon focuses more on the origin of different forms of Chi that stems from the interplay of the strengthened and weakened organs. Hence the constitution theory is “splanchnic” he asserts, and his methods to differentiate eight constitution types are in the process of being validated in clinical settings (Kuon, 1965; ecmed.org).

Based on Kuon’s interpretation of Bagua and Sasang typology, he states that “all individuals are categorized into eight constitutions.” In this thesis, the key concept of Bagua (entities in three dimensions) is taken in that it asserts eight entities to explain the causality of illness within individuals. No matter how valid Kuon’s eight constitution theory is proven to be in a hundred years from now, his ingenuity had been opened in scrutiny and in the process of clinical trials. The Eight Constitution Acupuncture and related rehabilitative therapies make the possibility of medicine wider for preventing terminal illness by knowing individualized connotations. With the hope of the preventive medicine in the world, this thesis discusses how Bagua relates to Six Consciousness to Twelve Meridian system in section 2.5, which provides the theoretical explanations for the social-ecological frames of ECHO.

2.5 Synthesis: Six Consciousness and Twelve Meridian Channels

Energetically Bagua symbolizes six temperature changes between sky (☰) and earth (☷) called Six Chi (육기) are analogous to six types of energy flowing between the head, the sky (☰) and the body, the earth (☷). These six energies in the body are called Six Consciousness (육경), which expand to the complementary pair of the feet and the hands that make up Twelve Meridians system (Kim, 1989). Six Chi (entities) between sky (☰) and earth (☷) are: 2. lake (☳), 3. fire (☲), 4. thunder (☳), 5. wind (☴), 6. water (☵), 7. mountains (☶). The Six Chi are factors to change the level of moisture (wet-dry) and temperature (cold-hot) in atmosphere. When Six Chi represent six different energies flowing in the human body, Six Consciousness the bases of twelve Meridian channels, which are the metaphysical representations of the Six Chi. Table 2.2 describes the Six Consciousnesses in a phonetic version of Korean, words in Korean, and Bagua representations. The Six Consciousnesses divide into to Three Yin (lake, fire, and wind) and Three Yang (mountains, water, and thunder).

As shown in Table 2.2 Bagua's representation of yin (⚊) and yang (⚋) are noted by dashes. Notice the order of yin's representation (⚊) in lake (☳), fire (☲), and wind (☴). The yin symbol moves from the top to the middle to the bottom. Yin moves in placement depending on the state (1st, 2nd, 3rd). This is the same in yang (⚋), mountains (☶), water (☵), and thunder (☳). The denotation of the six consciousness can be represented yes and no to each dimension in the ECHO.

Table 2.2 Table displaying six consciousnesses, modified from (Kim, 1989, p.66)

	Six Consciousness					
<u>Desires</u>	<u>Affirmation (YIN)</u>			<u>Denial (YANG)</u>		
1st: Physiological	Tae-Yin-Kyong	태음경	lake (2, ☵)	Yang-Myong-Kyong	양명경	mountains (7, ☶)
2nd: Emotional	So-Yin-Kyong	소음경	fire (3, ☲)	Tae-Yang-Kyong	태양경	water (6, ☵)
3rd: Intellectual	Kwol-Yin-Kyong	궐음경	wind (5, ☴)	So-Yang-Kyong	소양경	thunder (4, ☳)

In Table 2.2, notice Six Consciousness divided into three yin, the affirmation of three dimensional desires and three yang, the denial of them. Kim (1989) asserts three dimensions of the human body and the mind that affirms or denies the physical, emotional, and intellectual desires. The three-dimensional alternations of the yin and yang consciousness are continuously, seamlessly carried by the six meridian channels from the extremities (the hands and the feet) to the viscera and vice versa in which the hands and the foot set of Six Consciousness channels to make up twelve Meridians (refer to Table 2.3). As stressed repeatedly, Twelve Meridian system manifests contents and the shapes of contents. Hence, Twelve Meridian system shapes the human body as a three-dimensional object in three dimensions: the front, the back, and the sides. At 1st dimension, Tae-Yin-Kyong (☵) and Yang-Myong-Kyong (☶) govern the front of the body and the physical desire of the mind. At 2nd dimension, So-Yin-Kyong (☲) and Tae-Yang-Kyong (☵) govern the back of the body and the emotional desire of the mind. At 3rd dimension, Kwol-Yin-Kyong (☴) and So-Yang-Kyong (☳) govern the sides of the body and the intellectual desire of the mind.

As shown in Figure 2.1, MFW is arranged in the circular diagram by the name of the twelve organs associated with the meridians. For this thesis, the Table 3.3 rearranges Twelve Meridian channels by the flow of Six Consciousness: three affirmations and three denials of physical, emotional and intellectual desires. The order differs when the Meridians system is related to the time factor that when it is related to the space factor.

Within time factor, Chinses denotation is included in prentices to help refer to MFW in Figure 2.1; hence MFW depicts this time-factorized order: “Kwol-Yin-Kyong (厥陰經) » So-Yin-Kyong (少陰經) » Tae-Yin-Kyong (太陰經) » So-Yang-Kyong (少陽經) » Yang-Myong-Kyong (陽明經) » Tae-Yang-Kyong (太陽經)” and repeats the order once more (Kim, 1989, p. 95). In Six Consciousness, in parallel with Sasang diverting from the yin to the yang, the first three meridians are three yin in the order of the least to the most yin state. The following three meridians are three yang in the order of the least to the most yang.

This time-factorized order of Twelve Meridian system represents the order of natural rhythms and Six Consciousness of the persons that occur in time. First, we affirms intellectual desire (Kwol-Yin-Kyong), being curious all the time at this least yin stage. Then, when we reach puberty, we are searching for an emotional partnership (So-Yin-Kyong). At the most yin stage, we as adults seek financial stability and affluence (Tae-Yin-Kyong). Compared to the life cycle of annual plants, at the Kwol-Yin stage, plants sprout and grow. At the So-Yin stage, plants bloom with beautiful flowers at the end of the growth stage. At the Tae-Yin stage, the flowers of plants become fruits. At the So-Yang stage, the fruits of the plants stop getting fatter and grow the seeds inside. At Yang-Myong

stage, the fruits are drying themselves. Finally, at the Tae-Yang stage, the fruits of plants fall and go into the ground in the form of seeds in nature.

Within the space factor, since the Meridian energy paths are manifested in the body, the space, the flow of twelve meridians is determined by the interactive movement between each complementary pair, Tae-Yin-Kyong and Yang-Myong-Kyong which is the 1st dimension where the affirmation and the denial of the physical desires. Following is the 2nd dimensional interaction between So-Yin-Kyong and Tae-Yang-Kyong, where the affirmation and denial of the emotional desires occur. Lastly, between Kwol-Yin-Kyong and So-Yang-Kyong, alternating paths of the affirmation of the denial of the third dimension, the intellectual desires.

As delineated in Table 2.3, the alternative paths laid out in the body, and the cyclical order of how desires arise, the imbalances of 1st, 2nd, and 3rd desires are manifested within individuals in time and shows in the body as deficient or excess state. The imbalances change the shapes of the body that are going through specific the passages (1st, 2nd, and 3rd) and the state of the passages either deficiency or excess of yin or yang, four possible combinations. In sum, four possible combinations times three dimensions equals to twelve Meridians. With four combinations and the order of the combinations, the ECHO can construct the loop of the percepts (yin: taking) and actuators (yang: giving) in each dimension.

As explained in Table 2.3, the twelve meridians are energy paths that transfer three-dimensional signals of the physical, emotional and intellectual desires. The signals of each dimension begin at the viscera, to hands, to face, to feet and back to the viscera. Neural hypothesis of Meridian system explains (Longhurst, 2010) that sensory neural signals are

carried from four extremities to the brain and from the brain to the viscera through activating the peripheral and central nervous system. Astonishingly, the neural paths are parallel with the flow of the Meridian system (Stefanov et al., 2013; Lee et al., 2013) constructed by philosophers about five thousand years ago (Lei et al., 2014).

In Table 2.3, I omit denoting the Korean and the Chinese name to make it parsimonious and less convoluted. Here I recapitulate the order of twelve meridian flow with two denotations to help refer to the MFW Figure in 2.1. The order the first physical dimension flows from A to D: {A. Su-Tae-Yin-Lungs (수태음폐경, 手太陰肺經), B. Su-Yang-Myong-Large Intestine (수양명대장경, 手陽明大腸經), C. Jok-Yang-Myong-Stomach (족양명위경, 足陽明胃經), and D. Jok-Tae-Yin-Pancreas (족태음비경, 足太陰脾經)}. The order of the second emotional dimension flows from E to H: {E. Su-So-Yin-Heart (수소음심경, 手少陰心經), F. Su-Tae-Yang-Small Intestine (수태양소장경, 手太陽小腸經), G. Jok-Tae-Yang-Bladder (족태양방광경, 足太陽膀胱經), and H. Jok-So-Yin-Kidney (족소음신경, 足少陰腎經)}. The order of the third intellectual dimension flows from I to L: {I. Su-Kwol-Yin-Pericardium (수궐음심포경, 手厥陰心包經), J. Jok-Kwol-Yin-Liver (족궐음간경, 足厥陰肝經), K. Su-So-Yang-Triple Burner (수소양삼초경, 手少陽三焦經), and L. Jok-So-Yang-Gall Bladder (족소양담경, 足少陽膽經)}.

Table 2.3 Twelve Meridians

	Six Consciousness					
<u>Desires</u>	<u>Affirmation (YIN)</u>			<u>Denial (YANG)</u>		
1st: Physiological	Tae-Yin-Kyong 태음경 lake (2, 二)			Yang-Myong-Kyong 양명경 mountains (7, 七)		
the order (A to D)	Su (수, 手, Hands)	A	Lungs	Su (수, 手, Hands)	B	Large Intestine
the front	from the chest to the hands			from the hands to the face		
	Jok (족, 足, feet)	D	Pancreas	Jok (족, 足, feet)	C	Stomach
	from the feet to the chest			from the face to the feet		
2nd: Emotional	So-Yin-Kyong 소음경 fire (3, 三)			Tae-Yang-Kyong 태양경 water (6, 六)		
the order (E to H)	Su (수, 手, Hands)	E	Heart	Su (수, 手, Hands)	F	Small Intestine
the back	from the chest to the hands			from the hands to the face		
	Jok (족, 足, feet)	H	Kidney	Jok (족, 足, feet)	G	Bladder
	from the feet to the chest			from the face to the feet		
3rd: Intellectual	Kwol-Yin-Kyong 궐음경 wind (四, 四)			So-Yang-Kyong 소양경 thunder (4, 四)		
the order (I to L)	Su (수, 手, Hands)	I	Pericardium	Su (수, 手, Hands)	J	Triple Burner
the sides	from the chest to the hands			from the hands to the face		
	Jok (족, 足, feet)	L	Liver	Jok (족, 足, feet)	K	Gall Bladder
	from the feet to the chest			from the face to the feet		

To recap, Six Consciousness divide into three yin and three yang at the top by 1st, 2nd, and 3rd dimension of desires, the physical, emotional and intellectual respectively. In each yin and yang of the 1st dimension, there are four links in the order to complete the loop: the chest & stomach » the hands » the face » the feet » the chest. Generally speaking, the flow in each dimension begins at the viscera to the extremities and back to the viscera. In terms of agencies, the order represents the interactive loop from the percepts and

actuations for situated agents, who are going to be modeled by the states of three-dimensional desires.

2.6 Summary

To excel the cooperation of situated agents, this thesis adheres to build social intelligence for autonomous agents to understand “social-ecological dependence.” Actualizing this cooperative society, this thesis proposes the generalized mechanism to emerge altruistic norms among situated agents. Due to the subjective errors and noises in the world, normative agents are inefficient and ineffective in reasoning social-ecological dependencies. Communicating altruistic norms to construct or reconstruct the value systems in the society, thesis supports embodied cognition (Thelen et al., 2001; Barsalou, 2008; Dolan et al., 2012) with “inseparable from the whole of context-dependent, life-motivated, embodied activity” (Paolo et al., 2014, p. 35). The “enactivism may be construed as a kind of nonreductive, nonfunctionalist naturalism” (Paolo et al., 2014, p. 36) for agents to attain social-ecological rationality. In speculation, the Meridian system and the theories of Chi, Taijitu, Sasang and Bagua are scrutinized to conceptualize ECHO for situated agents. The Meridian system seamlessly connects the environment and the person with the priori factor called Chi (energy). Taijitu, the flux of the yin and yang energy, equalizes the energy in vacuum; however, phenomenologically, the yin and yang must alternate the energy potential to exist. Four psychological traits in Sasang and eight entities in Bagua constitute the individualized medicine in TKM. The synthesis of Taijitu, Sasang and Bagua configurate Twelve Meridian system displayed in MFW. The system of Twelve Meridian shows the orientation of the parsimonious eight constituents defined by three dimensional individualized traits within twelve ordered, natural processes. This

thesis proposes the model of ECHO to explain the reciprocal, cyclical internalization of altruistic norms for situated agents.

CHAPTER 3. THE ECHO MODEL

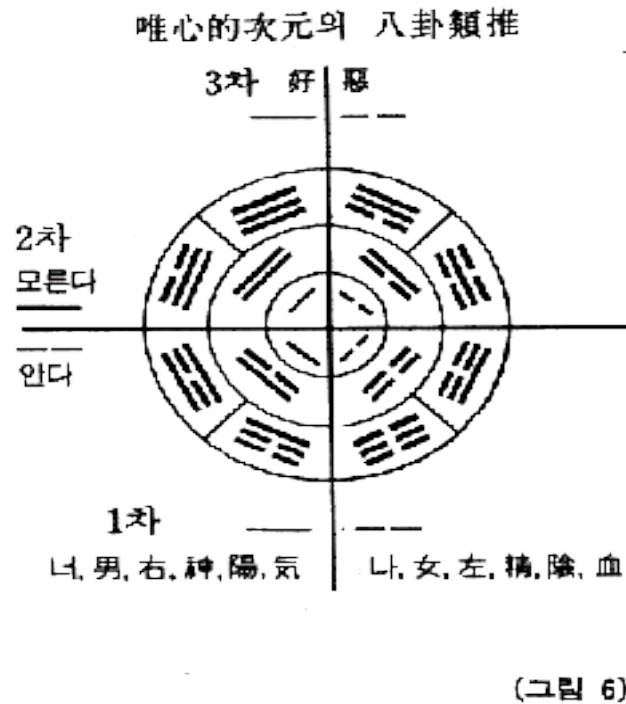


Figure 3.1 Three-Dimensional Shift in Yin-Yang

The ECHO model stems from the diagram shown. The symbols in three circles and a cross in the center “represent at glance” the zest of the yin-yang transformations in three dimensions. Kim (1989) interprets Bagua (팔괘; excluding the outermost circle divided in twelve parts in Figure 3.1) and develops three-dimensional representation above (p. 66). Since the beginning of 1980s, he has been an icon, advocator, and public speaker of Korean Traditional Medicine (KTM) movement in Korea. This diagram, drawn by Kim, calls for meditative speculation to study full classical manuscripts rather than brief versions of those classics.

Beginning with the diagram by Kim (1989) in Chapter 3 this thesis conceptualizes ECHO to explain the internalization process of agents that recognize and represent symbols

and events in a way that agents can quickly make sense and give meanings for one another. From this internalization, agents can “emerge” value system within, three dimensional characteristics and around themselves, namely social norms. The focus of the thesis is to make agents as adaptive as possible by knowing and applying the rules of social-ecological environment that exist as “ends” rather than “means.” This thesis further delineates how the internal and external world should be represented in yin-yang energy system and finally at twelve Meridian system that is the base unit of the cyclical flow defining the social-ecological frame of ECHO model.

The key point in understanding Meridian system (represented by meridian name), is not focusing on the viscera, e.g., neither the kidney nor the liver. In other words, not the kidney but should Jok-So-Yin energy, not the liver but Jok-Kwol-Yin energy we must focus. ‘Meridians are the paths where our thoughts [implying six consciousness in table 2.3 and 2.4] flow through’ and this statement must be the underlying, accepted condition, at which we start to investigate what each meridian stands for. Only if we start there, then we can understand what meridian system is.

(Kim, 1989, p. 47).

Bagua deduction represents the constitutional entities, the exclusive shapes and the definable contents within the shapes. For the scope of the thesis, Bagua are interpreted to eight symbolic, stand-alone agencies that integrate and construct the meanings of their social-ecological environments. The environment further divides into twelve meridians in

time factor added to space. In short, the changes in third-dimensional yin and yang division bear individual subjects that can observe, experience and “cause” the changes of environments. *The Book of Changes* (주역; 周易) identifies sixty four “natural” rules (Bagua times Bagua) which can be factorized by eight rules of Bagua depicted in Figure 2.4. Kim (1989) points out the shortcomings in any classification system in that all things exist before humans to categorize and name them. The intuitive, intellectual categorization and interpretation in Bagua guides associative, causal changes of all things in three-dimension, where we as humans perceive the world.

3.1 ECHO Orientation Rules

It appears a thermostat to implicitly detect temperature changes and actuate its environment accordingly because the thermostat is an autonomous agent encapsulate its working mind from other agents. Situated agents however keep in mind that deliberating their jobs can be dependent from one another’s functional outputs in terms of social-ecological structures and cooperating situations. The kind of social intelligence of situated agents that emerge to orient themselves to be self-aware of and how they are connected in the society of mind to produce adaptive links at hand both structurally and socially. To do self-orientation and self-organization, ECHO agents operate with equalizing, complementary and heuristic orientation.

Firstly, by equalizing, ECHO agents can always alternate their state from the yin to the yang. In nature, anything cannot persistently maintain one’s constituent characteristics. An example: for a seed to exist “as a seed” continuously without getting rotten away in time, it must be kept in a vacuum; otherwise, the seed must go through the cycle of the

alternation of the yin to the yang to produce its next generation. For ECHO agents, by equalizing, their constituent energy-make-up must be sustained within social-ecological interactions, e.g., aloe plants sustain life due to the cold fluid inside their stems to equalize plants' energy regarding the dry, hot temperature in a desert.

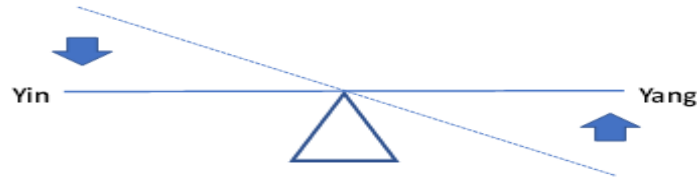


Figure 3.2 Equalizing: the seesaw-like balance. (Kim, 1989, p. 306)

As shown in Figure 3.2, the excessive yin state can be addressed in two-way: addition of the yang or negation of the yin. In analogy, a cup is soon emptied if it keeps getting taken water away without adding water to it. So, this cup to give water or take water in, it needs to always be a half full. Additional expressive power of the addition and negation of seesaw-like balance the yin and yang relativity, in contrast to a thermostat-like singular linearity, ECHO agents can quickly represent the excess or the lack of either the yin or the yang at the same time so to be self-aware of the internal states for keeping the representation of navigational orientation in social-ecological interactions.

The Equalizing mode of ECHO is intrinsic and continuous meaning throughout three-dimensional transformation of Chi: the physical, emotional and intellectual dimension. It mirrors the mechanism of Taijitu discussed in section 2.4.2 extensively. As Taijitu is the first dimensional transformation of Chi, in Taijitu, the potentiality of yin-yang

is always in flux to balance one another in the time of excess. With one another existing in time and space, two phenomenological qualities of the mind can either affirm or deny the desires of the physical, emotional, and intellectual dimension. (Kim, 1989). The equalizing rule applies to ECHO agents' altruistic transformation by the alternation: from the yin state seeking physical desires to maintain the self (yin, - -) to the yang state refusing the self-maintenance for others (yang, —), e.g., fire (yang) burns itself to give a light in the dark or heat in cold. All living organisms practice sacrificial or yang qualities to maintain the life of the whole.

Secondly, by seeking out a complementary set, ECHO agents orient themselves to carry out social-ecologically rational interactions: give and take in each dimension. There are two Sasang and four Bagua complementary sets. In two Sasang complementary sets, agents can orient themselves by emotional themes to individualize their own morality exclusive from one another. The exclusion makes one another complementary. The benevolent agents from feeling sorrow and impulse give themselves to lead and guide the mess, and they are complementary for the courteous agents from feeling happiness and fear, who would be content to be guided by the leaders. The righteousness agents feeling anger and anxiety desire to fight for the people as warriors, and they are complementary for the wise agents feeling enjoyment and nervousness who are thinkers and more likely to strategically fight for others behind the enemy line.

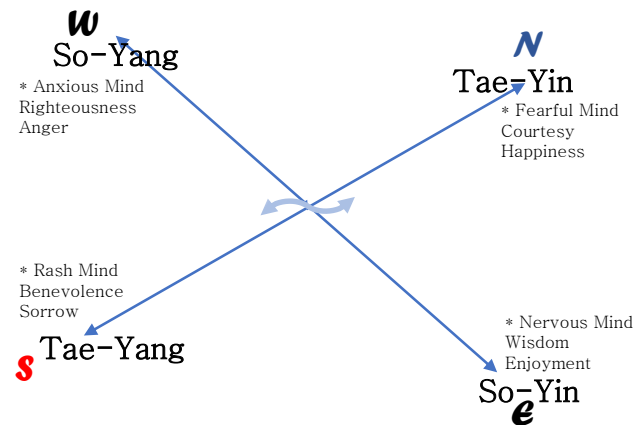


Figure 3.3 Sasang Complementary Sets

Note: Modified from (Kim & Pham, 2009) by adding the description of the mind.

Another complementary sets are defined within individualized entities rather than having the morality psychological traits. Recall that each Sasang divides to two Bagua entities. For instance, the benevolent agents are sensitive in feeling sorrow and impulse, but they can be “physically” manifested either “sky (☰)” or “lake (☶).” The division means, the sky agents are “inspirational leaders” by giving up all three-dimensional desires; however, in reality even in all giving inspirational leaders, they do need to seek out the intellectual wisdom. The lake agents are the leaders who are seeking the intellectual wisdom while taking care of others physically and emotionally.

Recapping the four complementary sets defined in section 2.4.4, the two demotions of Bagua entities are consistent throughout this thesis, so be cognizant with the numbering by numbering and names in prentices: (1. sky vs. 8. earth), (2. lake vs. 7. mountains), (3. fire vs. 6. water), and (4. thunder vs. 5 wind). Examine the division described graphically

in respect to Sasang four directions shown in Figure 3.4. Tae-Yang divides to sky and lake, Tae-Yin divides to earth and mountains, So-Yin divides to fire and thunder, and So-Yang divides to water and wind. When ECHO agents are situated to become cooperative, these complementary Bagua sets orient agents to be self-aware of themselves in respect to complementary sets. By carrying out their morality emotions, ECHO agents can identify one another's complementary sets by playing social-ecological roles, e.g., leaders and followers, warriors and thinkers.

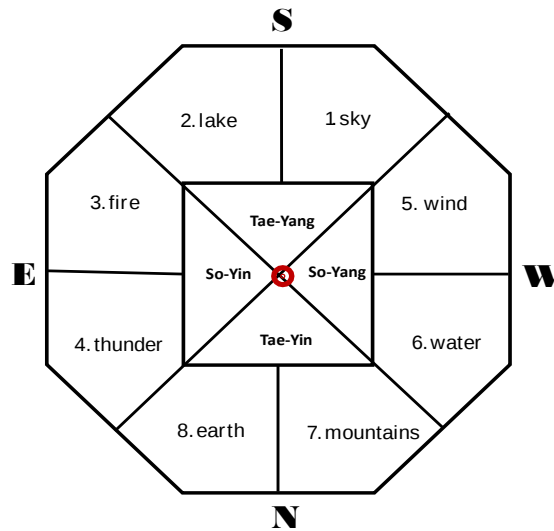


Figure 3.4 The Division from Sasang to Bagua

Thirdly, refining the recognition and representation methodologies are beyond the scope of this thesis; however, instead of complicated affective recognitions and representations, the identities of ECHO agents can be signalized and identified by the individualized, simplistic binary denotation in each dimension. By using simple yes/no

heuristics in which yin symbol (- -) denotes ‘yes’ written y and yang symbol (—) denotes ‘no’ written n, ECHO agents can communicate and request a complementary pair to equalize. In communication, the signals can be comprised of three letters denoting eight entities. Number 1 sky (☰) can be denoted as ‘nnn.’ Number 2 lake (☵) can be denoted as ‘ynn.’ Number 3 fire (☲) can be denoted as ‘nyn.’ Number 4 thunder (☳) can be denoted as ‘yyn.’ Number 5 wind (☴) can be denoted as ‘nny.’ Number 6 stands water (☶) can be denoted as ‘yny.’ Number 7 mountains (☶) can be denoted as ‘nyy.’ Number 8 earth (☷) can be denoted as ‘yyy.’ The denotation of Bagua complementary sets are iterated in numbering, names and three-letter-denotation) in pretexts for clarity: (1. sky ‘nnn’ vs. 8. earth ‘yyy’), (2. lake ‘ynn’ vs. 7. mountains ‘nyy’), (3. fire ‘nyn’ vs. 6. water ‘yny’), and (4. thunder ‘yyn’ vs. 5. wind ‘nny’). Besides this three-letter denotation can also represent the coordinates of ECHO agents’ social-ecological status by using Cartesian coordinates: x, y, and z axis, ECHO agents can orient themselves within three dimensional, social-ecological frames to denote one another’s orientation graphically.

For defining the extension of affective computing (Picard, 2003) to model ECHO, the representation of Six Consciousness can be simple enough to model social-ecological interactions. An article by Duffy (2003) illustrates the practical view on the anthropomorphism in social robots, saying “the stance of weak AI where computational machines, sensory and actuator functionality are merely a concatenation of processes and can lead to an illusion of intelligence in a robot primarily through projective intelligence on the part of the human observer/participant” (p. 179). In the article, the conceptualization of the rationality in the extent of anthropomorphism “is attributing cognitive or emotional states to something based on observation to rationalize an entity’s behavior in a given social

environment” (Duffy, 2003, p. 180). The ECHO model utilizes emotional states as expressible in shapes and moral mannerisms discussed in section 2.4.3 and 2.4.4.

3.2 ECHO Three Dimensional Heuristics: Six Consciousness

As discussed in section 2.5, there are six temperature changing entities between ‘sky (☰)’ and ‘earth (☷)’ and they are: 2. lake (☵), 3. fire (☲), 4. thunder (☳), 5. wind (☴), 6. water (☶), 7. mountains (☶). These six entities are factors to change the level of moisture (wet-dry) and temperature (cold-hot) in atmosphere and inside the earth. The weather changing six elements stand for Six Consciousness (Kim, 1989) to explain the energetic changes the human body. Six different energies flowing in the human body then multiply by two due to connecting the paths from the hands and the feet to become Twelve Meridian channels. In three-dimensional graphical heuristic of ECHO, these Six Consciousness can be defined in Cartesian coordinates by refining the degree of the yin and yang state of each dimension (the physical, emotional and intellectual respectively) of situated agents, depending on applicable scenarios of ECHO.

The Figure 3.5 show the pre-collapsing lines shown at sky and earth entities. The following Figure 3.6 shows the collapsed line in blue and two three-dimensional representations, lake and mountains respectively drawn as examples. In analogy, collapsing two blue lines in Figure 3.5 represents the energy flow of six Consciousness throughout the body in three dimensions. Refer to the Figure 3.6 the collapsed vertical line denotes the third dimension, the vertical line symbolizes the head, 1 sky on the top and the viscera, 8 earth at the bottom. The 3D representation is useful for categorizing ECHO agents in real situations. More intuitively, the dimension represents agents’ capabilities in

perception and actuation on environments. A worm taken by a bird one morning cannot reason the causality of its death (Kim, 1989). In other words, the mountains agents (☶) with all yin state in three-dimension cannot “perceive or act upon” the second and the third dimension. The mountains agents become altruistic to the lake agents (☵).

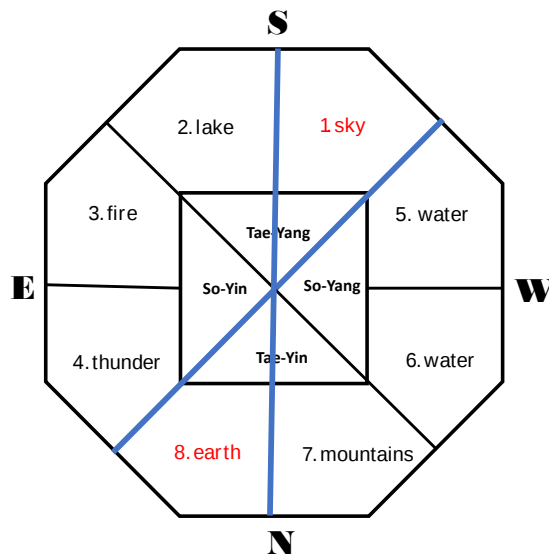


Figure 3.5 Six Consciousness Where Sky and Earth Lines Collapsed at a Vertical Axis

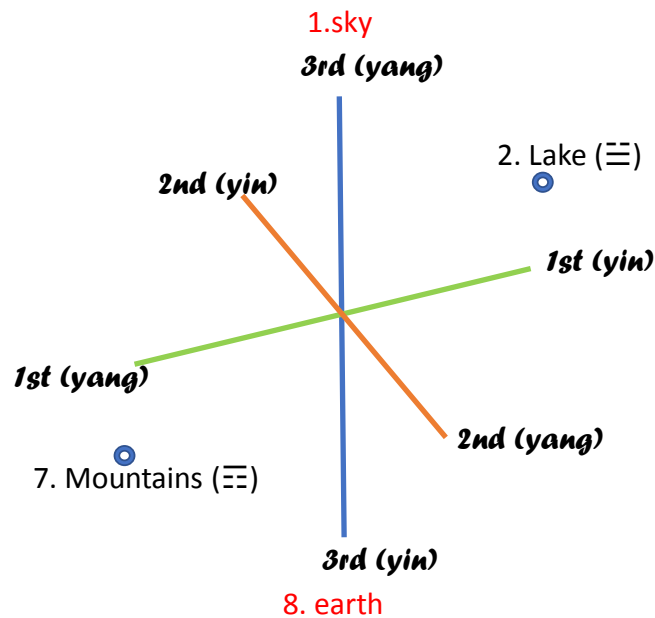


Figure 3.6 Three-Dimensional Heuristic of Six Consciousness

Kim (1989) asserts individual differences arise when the tenacious, psychological energy flowing through each dimension. Each dimension of ECHO agents are more likely initialized by the parameters of percepts and actuations. Four meridian channels in each dimension represents the loop of perceptions and actuations within ECHO agents when they are evolving in time if possible. By applying Sasang and Bagua complementary sets in agents' social-ecological interactions, ECHO can emerge the compete sets of social networks that can effectively become altruistic to meet systems' goals. After all, humans would not get acquainted with someone or something in random. It is through this

psychological tendency and deliberation of one's goals that construct and integrate information coming from one's social nets. To delineate these "systematic; not random" social nets emerging from agents' perspective: to decide what to give and what to get, the ECHO model frames "navigational abilities for situated agents," consisting of equalizing, complementary and heuristic orientation to be cooperative. In section 3.3, this thesis graphically presents the social-ecological frames to integrate the external and internal world of ECHO agents by the extension of the ubiquitous Chi that connects all.

3.3 ECHO Social-Ecological Frames: Sasang, Bagua and Twelve Meridian Channels

Orientation is the most fundamental concept in the ECHO that is derived from the extensive analytics of the eastern, classical philosophy that had become the bases of alternative healing and medicines. No knowledge or the representation of knowledge meaningful if there is no reference point to the representation. Truth or facts only make sense in relativity. Building orientation for situated agents calls for the constant awareness of connections and relative positions to either geographically or psychologically (전체성과 상대성) and fast access to the conscious awareness so that agents can maintain orientations.

To manifest "orientations" to machines, the theories of the yin-yang, Sasang, Bagua and twelve Meridians are explained for providing the representation of connections and relativity. As shown in Figure 3.7 and Figure 3.8, four situated ECHO agents that evolve in time, the pyramid shape of the complementary sets can make sense more to be self-aware of themselves in respect to their evolving minds. Cartesian coordinates in Figure 3.6 are more effective in displaying the social-ecological interactions between situated

agents. The pyramid ECHO heuristics can match social-ecological interactions that agents can pursue on demand. Numbering and Bagua name in the bottom of the pyramid are: 2 lake, 4 thunder, 6 water, and 8 earth. Numbering and Bagua name in the four sides of the pyramid are: 1 sky, 3 fire, 5 wind and 7 mountains. Their complementary sets are: (1. sky vs. 8. earth), (2. lake vs. 7. mountains), (3. fire vs. 6. water), and (4. thunder vs. 5. wind). For instance, refer to Figure 3.8: the status of the mind begins at 1, due to the intersected points and adjacent polygons, e.g., 2, 3, 5, and 7, the mind of 1 can evolve in four ways.

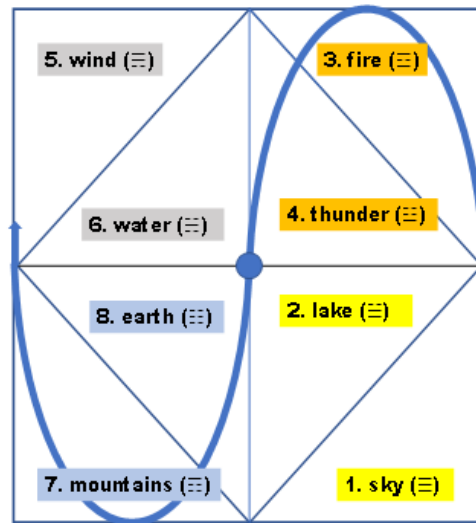


Figure 3.7 Repositioning Bagua

Note: This Figure is meant to show the interactive, complementary sets in three dimensions. The diagram is an unfolded, pyramid shape with a square base (5-sided, 4 triangular faces, 1 square face in the bottom).

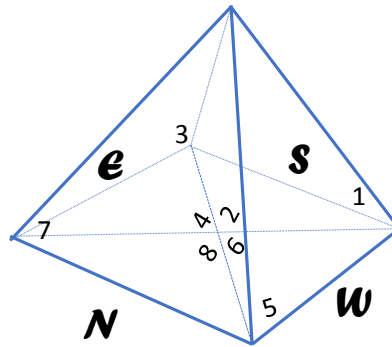


Figure 3.8 Bagua Orientation in the Pyramid with a Square Base

Figure 3.9, 3.10 and 3.11 show the representation of ECHO social-ecological frames to make agents to orient themselves in complementary social-ecological environment accordingly. With the ECHO model, this thesis laid out the framework that paths in the body; hence cognitions of agents are grounded to internalize symbols and events for making them sensible to agents as “percepts.” Because these percepts can differ from an agent to another, this thesis had given the extensive, comprehensive explanations of theoretical framework so that agent modelers can understand the general framework of the ECHO so to be flexible and creative depending on their concerns in developments. Twelve percepts in the ECHO model field as the circle connected to the octagon and the square in Figure 3.9, I claim that twelve percepts are constructs, building blocks of the mental objects that can make sense of agents’ world to actuate and deliberate systems’ goals. The social networks designed in Figure 3.11, as Minsky mentions about the society of the mind, the

ECHO echos that the minimal but very comprehensive building blocks to make mental objects that are fast in making sense of the world within and outside.

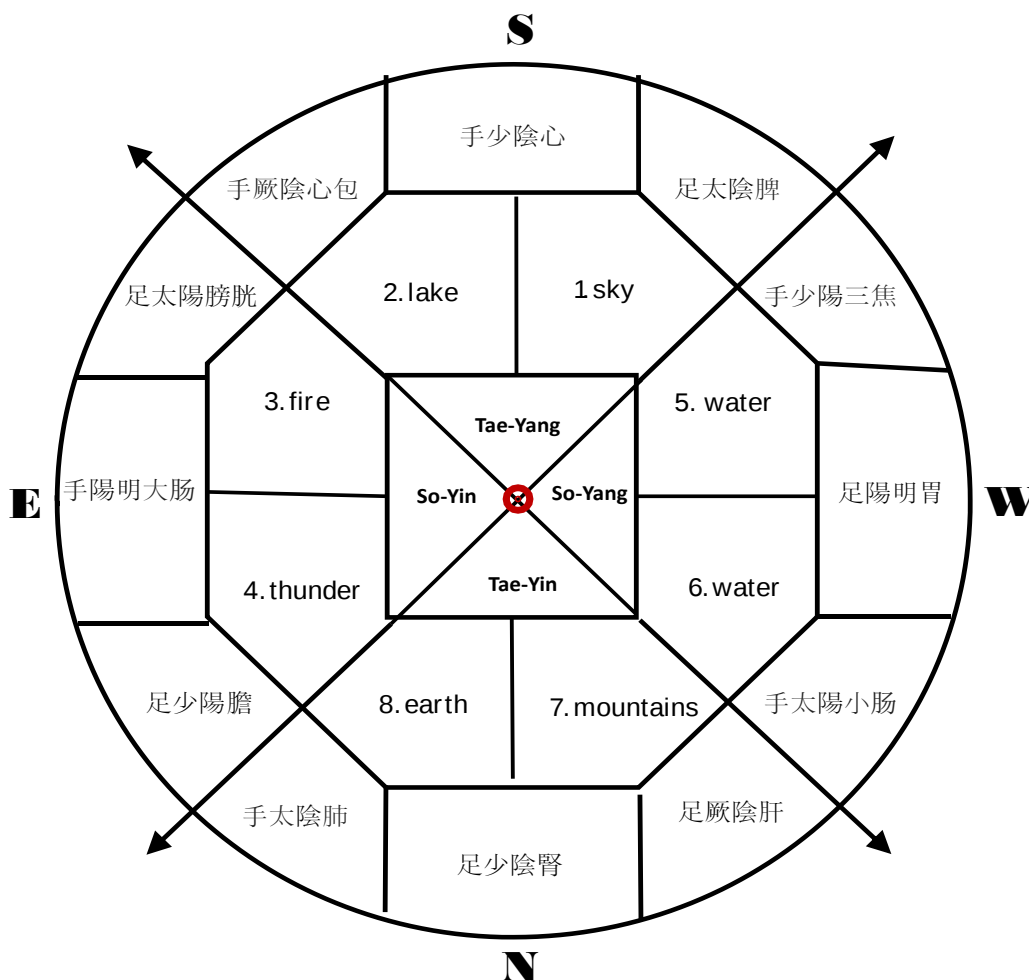


Figure 3.9 The ECHO Social-Ecological Frames: Sasang, Bagua, and Twelve Meridians

Note: The square (Sasang) “internal” representation, the octagon (Bagua) “entities as subjects” representation, the circle (Twelve Meridians) “external percepts guided by psychological traits/tenacity from Sasang).

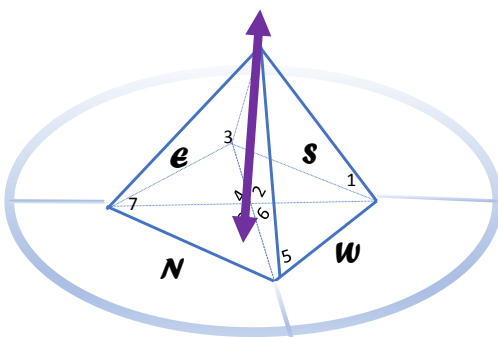


Figure 3.10 ECHO Social-Ecological Frames in Three-Dimensional Representation

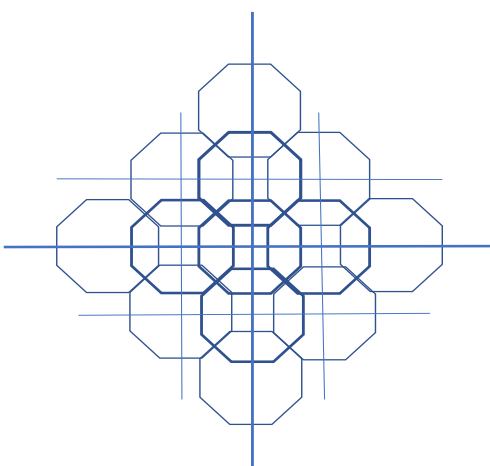


Figure 3.11 ECHO Social Networks

Discussed in section 2.5 and displayed in Table 2.3, twelve percepts are internally represented in the flow of four meridian channels in each of three dimensions: the physical, emotional and the intellectual desires. Twelve actuations are externally operationalized in the flow of time in nature shown in Figure 2.1 the diagram of MFW. To clarify twelve percepts for situated agents to “become altruistic and cooperative,” ECHO agents are seeking for things what their complementary agents would give. The utility of Table 2.3 comes at the expressive, integrative power of the twelve-meridian paths (three dimension by four flow in each dimension) that can be initialized in specific to agents. For instance, an agent can be defined by three-dimensional heuristics discussed in section 3.1, p.71; and therefore, the flow of meridian paths can be defined its percepts and actuations. The distinction between motivations and externalities of situated agents is clearer as well as more integrated due to twelve systematic paths laid out as passages of information processing internally (the flow of Six Consciousness; Table 2.3) and externally (the flow of time; Figure 2.1).

The loop can process the systematic integration between the voluntary movements of the extremities and the involuntary activities of the organs that are related to specific meridians. In table 3.1, this thesis attempts to delineate the percepts and actuations in Bagua entities to link the roles agents can play in social-ecological frames.

Table 3.1 The Complementary Eight Entities and Four Psychological Tenacity

Quadruple (Sasang in Bagua) Complementary Processing							
					YANG (☰)		
			<i>Tae-Yang</i>			<i>So-Yin</i>	
	Sasang images		<i>Benevolence</i>			<i>Wisdom</i>	
	Bagua images	Sky (1, ☰)		lake (2, ☶)		fire (3, ☲)	thunder (4, ☳)
	Korean denotation	독맥		태음경		소음경	소양경
	Chi quality	ascending (heat)		moist (heat)		hot (fire)	light (fire)
	Actuations	leading		foraging		others-preserving	unlearning (discarding)
	Tenacity	innovative		affluent-seeking		social	aggressive
	Percepts	compliance		hunger		self-dependency	mastery
	Cubic Heuristics	nnn		ynn		nyn	yyn
TAIJITU							
	Cubic Heuristics	yyy		nyy		yny	nny
	Percepts	authority, commands		satiation		self-sufficiency	incomprehension
	Tenacity	conventional		piercing		independent	curious
	Actuations	following		purging		self-preserving	learning (remembering)
	Chi quality	descending (cold)		dry (cold)		cold (water)	change (wind)
	Korean denotation	임맥		양명경		태양경	궤음경
	Bagua images	earth (8, ☷)		mountains (7, ☶)		water (6, ☵)	wind (5, ☴)
	Sasang images		<i>Courtesy</i>			<i>Righteousness</i>	
			<i>Tae-Yin</i>			<i>So-Yang</i>	
					YIN (☷)		

The six complementary sets of twelve Meridians can act as the equalizing seesaw-like balance within time and space orientation. Ultimately, the principle of the yin-yang balance existed in Taijitu is how the ECHO model can quickly pick what to do next by paired orientations and the equalizing with the complementary pair is the heuristics the mind and the mind activate. The important notion in the ECHO model, in respect to agents' social intelligence and their adaptabilities, is that the representations of emotions and thoughts can no longer to be “reactive layers” that intervenes the deliberation of agents. They are continuous, selfhood forming mechanisms that runs at all times to support the deliberation of agents' goals. Therefore social, adaptive intelligence is no longer as additional or some constraints in need of interventions. With the ECHO model, agents are

purposeful at all times with multiple goals by being self-aware of the social-ecological orientations when situated.

3.4 Summary

Castelfranchi and Paglieri (2007) explain “*cognitive functionalism*: the significant and heuristic categories of mental representations (e.g. beliefs and goals) are defined by their functions, rather than by their format, content, or other intrinsic features” (p. 239). Since beliefs and goals are secondary representation of what the world is, especially, in social-ecological interactions, the “mental” representations lack in immediacy because agents are cognitively interpreting the minds of others. However, the adaptability and “functionality” of these beliefs and goals are most debated in terms of what constitute to change their statuses and contents and how often should they be updated corresponding to situations. Ecologically rational organisms maintain simple search rules, simple stopping rules, and simple decision rules, in which all three adhere to circumstances that take place (Selten, 1998; Gigerenger & Selten, 2002).

Recent decades of research consist of the secondary reviews of theories applied in complex systems of previously published articles without much changes in agent architectures proposed. To conceptualize an embodied approach to social intelligence for situated agents’ orientation about the world around and themselves, ECHO agent modeling can close the gap between social-ecological dependences and autonomy of agents. The ECHO eliminates the unintended disconnection and the time lags between the mind and the environment by orienting agents to be self-aware and how they are connected in the society of mind to produce adaptive links at hand both structurally and socially. Agents are coupled with complementary pairs to be cooperative and situated to construct social-

ecological environments represented by the morphological typology of eight entities based on their specialized emotions that induce the patterned perceptions and actions.

Instead of looking at emotions as a process, in ECHO, emotions become “representations” that enable “adaptive, unambiguous communications” between agents. ECHO uses the emotions of agents as a whole to connect perception and actuations of the agents. This means that each agent is an emotional processor as a whole that produce predictive, cooperative behaviors for the society of the mind. The representation of eight parsimonious entities that are subjectively specializes in the strongest emotion based on persisting, intrinsic theme of the mind (Sasang). Eight entities in four complementary sets are social-ecological rational choices to be cooperative. Moreover, eight entities are the specialized agents that encapsulate the internalization of implicit and explicit symbols and events thereby creating symbols and events by their strongest emotions and intrinsic mind themes. Because ECHO model works for situated agents to be cooperative, what ECHO provides in this thesis is to how agents can self-organize to be a constituent in social-ecological frame to acclaim agents’ delegated roles in the society and become a necessary process to be efficient, effective in producing appropriate cooperation to meet the system’s end goals.

CHAPTER 4. DISCUSSION

To model cooperative, altruistic behaviors to be emerged for situated agents, ECHO transcends subjective communicative errors, called qualia by modeling “give and take” social interactions. Social behaviors should not be reduced to the mind; hence, cognitive architectures are less effective in capturing the essence of adaptive behaviors commonly observed in nature. To make sense of the adaptability of situated agents, the thesis has discussed three dimensions of agencies, namely the physical, emotional, and intellectual desires, to individualize agencies. The individualized, three dimensions are the parsimonious eight entities derived from the transformation of Bagua (refer to section 2.4.4). For social domains to be efficient and effective in meeting the collective goals, agents must work for the self, others and the society as a whole when situations demand such cooperation. ECHO efficiently and effectively guides situated agents to “become” altruistic” when necessary.

For instance, a common thermostat agent is a self-governed agent and can work coordinatively with a heating and a cooling system in space. It knows time and some mental rules to output a room temperature properly. For this thermostat agent, knowing any changes in multiagent home system is out of its capability. By ECHO this thermostat agent can orient itself belong to the first dimension of the physical mechanism meaning the thermostat agent is stationary on the wall and with one percept or one actuator to communicate a current room temperature. The thermostat agent for its existence alternates from the yin affirming to receive resource when it is under the threshold to the yang “denying” to receive resource when it is above the threshold. In three dimensional

heuristics, the thermostat agent is 8 earth (☷), a completely submissive agent and its role is in social-ecological frames “a yes agent” and graphically represented at the bottom of 3rd axis shown in Figure 3.6. The bottom orientation of “earth” agent means that directions or orders are coming from the above and the thermostat agent will say “yes” to receive and follow them. In evolution in time when the yin (yes) state of this agent is above the threshold, “earth” agent becomes 7 mountains agent (☶) to play a “altruistic” role to give resource to and in rare cases evolves to 2 lake agent (☵) for passing the orders, directions and information to others.

To initialize ECHO agents, their parameters are determined by three-dimensional monitoring capabilities of visual, textual, hearing, and so forth. How many percepts and capabilities of percepts are important factors to orient agents in three dimensions. A robot vacuum, for an example, with only mobile function is categorized lower in dimension than the one with visual monitoring to prevent collision. This initialization of three-dimension value can be categorical (yes or no) in eight entities shown in Bagua. However, by using integers the parameter value can be more refined in the representation of Cartesian coordinates shown in Figure 3.6. Due to its generalizability, ECHO can simulate the emergence of social-ecological networks represented in Figure 3.11 by setting either categorical or integer parameters.

In another intuitive scenario to explain ECHO model in action, let robot vacuums in a company building are demanded to be cooperative to locate an intruder hiding in the building. All robot vacuums have motion detectors and some memory to configure their assigned rooms. The Wifi function reports the location of a robot when it is docked to

recharge its battery at night. Every room has a robot vacuum. By the mid-night all robot vacuums are docked. By its own production rule, a robot's motion detector is turned off when a robot vacuum is docked but the Wifi is connected. The Wifi connectivity is typically used by these robots to report their locations every night or defined abnormal interruptions when arise. The reporting of an intruder is not the robot's routines. In this scenario, a robot's altruistic report of an intruder is not a routine defined at the design time of a robot vacuum.

In ECHO, due to its percept and actuator parameters explained, a robot vacuum is a fire agent (☲) when they are vacuuming; it is avoiding collision to others and walls to clean the area, the horizontal plane. Its percept is detecting motions horizontally to avoid collision. When it is docked at night, the robot vacuum can be initialized by ECHO to becomes a water agent (☵). Recall the principle of the ECHO equalization: the alternation of the yin and the yang within an entity to exist or the interaction with the complementary set between entities to exist. The water agent mode, the robot can send out its location signal when it is asked (by a consciousness above the robot) to turn on its motion detector and to report there's a motion detected or not. The robot knows nothing about an intruder, but it is asked to report there's a motion detected or not; by ECHO, it does what it is told because the mode of the robot vacuum is changed from a fire agent (☲) to a water agent (☵). In this scenario, the mode is switched by the timestamp, but switching the mode can also be sent by the Wifi as well, which can be designed when a robot vacuum is built.

Depending on applications, ECHO can be more generalized by using these non-routinely signals built on multi-agent systems switching between the prosocial mode from

the antisocial mode. Nonetheless, the proof of the concept simulation is necessary to validate the model ECHO. For situated agents' social-ecological interactions, the simple rules of equalizing, complementary heuristic orientation of situated agents can provide the simplistic mapping of the society of the mind to appropriate, cooperative links on demand. Designing these three-dimensional desires and the status of each dimension, within the self and within social-ecological environments communicated by ECHO, situated agents can determine when to be purely "selfish" deliberating their goals but, by using their routines, always can become altruistic to initiate, and maintain the efficient, effective changes functional to situations.

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