

A Framework for Virtual Assistants: An exploratory study

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Abstract

A virtual assistant (also called a virtual assistant) is an application program that can understand natural language and complete (electronic) tasks for the end user. Voice-activated digital assistants are becoming a bigger part of our lives. Talking to an Artificial Intelligence agent is expected to become an important and useful way humans interact with our computers. Companies in Information Technologies industry have taken serious steps to develop and introduce products enhanced by virtual or digital assistants. In this paper we attempt to conduct a preliminary study on virtual or digital assistants and propose a framework for the development of virtual or digital assistants. A preliminary list of recommendations is also included.

Keywords: Digital assistant, virtual assistant, framework, artificial intelligence, artificial intelligence agent

1. Introduction

Artificial intelligence (AI) is defined as the intelligence exhibited by machines. According to Russell and Norvig (2003), an ideal "intelligent" machine is a flexible rational agent that perceives its environment and takes actions that maximize its chance of success at some goal. The term "artificial intelligence" is colloquially applied when a machine mimics "cognitive" functions that humans associate with other human minds, such as "learning" and "problem solving" Russell and Norvig (2009).

An intelligent agent (AI) is an autonomous entity which observes through sensors and acts upon an environment using actuators (i.e. it is an agent) and directs its activity towards achieving goals (i.e. it is "rational", as defined in economics (Russell and Norvig (2003)). Furthermore, an intelligent agent may also learn and use knowledge to achieve its goals. Other definitions of AI are discussed in Franklin and Graesser (1996) and Kasabov (1998). AI agents may be very simple or very complex. Russell & Norvig (2003) classify AI agents into five classes based on their degree of perceived intelligence and capability:

- simple reflex agents
- model-based reflex agents
- goal-based agents
- utility-based agents
- learning agents

Please also refer to Franklin and Graesser (1996) for taxonomy for Autonomous Agents. Weiss (2013) claims that the following four classes of agents should be considered or studied:

- Logic-based agents: the decision about what action to perform is made via logical deduction
- Reactive agents: decision making is implemented in some form of direct mapping from situation to action;
- Belief-desire-intention agents: decision making depends upon the manipulation of data structures representing the beliefs, desires, and intentions of the agent; and finally
- Layered architectures: decision making is realized via various software layers, each of which is more or less explicitly reasoning about the environment at different levels of abstraction

AI agents are also closely related to software agents (autonomous computer programs that carry out tasks on behalf of the end users). The term intelligent agent may be used to refer to a software agent that has some intelligence, regardless if it is not a rational agent by Russell and Norvig's (2003) definition.

A virtual assistant (also called a virtual assistant) is an application program that can understand natural language and complete (electronic) tasks for the end user. Voice-activated digital assistants are becoming a bigger part of our lives. Some major or big players are convinced that talking to an AI agent will soon become an important and useful (or even dominant) way humans interact with our computers and take serious steps to develop and introduce products enhanced by virtual or digital assistant. For examples, Apple has Siri, Amazon has Alexa, Microsoft has Cortana, and Google has the refreshed Google Assistant.

In this paper we attempt to conduct a preliminary study on virtual or digital assistants and propose a framework for development of virtual or digital assistants. The rest of the paper will be organized as follows. Section 2 provides reviews of some of the major theories of human needs and motivations. Section 3 includes a short discussion on the roles humans play and the actions persons take. Section 4 deals briefly with some issues related to virtual or digital assistants. Section 5 includes the proposed framework for virtual or digital assistant development. Finally, Section 6 concludes the paper with some discussions and recommendations.

2. Human Needs and Motivations

A need is something necessary for an organism (including human being) to live a healthy or normal life and can be objective and physical (e.g., the need for food), or psychological and subjective (e.g., the need for self-esteem). There are also needs of a social or societal nature.

Needs and wants have been a subject of study and of interest in, and form a common substrate for, the diverse fields of philosophy, biology, psychology, social science, economics, and politics, etc. For an overview of human needs, please refer to Dover and Joseph (2008), and Dover (2015). In the following, we briefly review and summarize some of the major school of thoughts or theories in a roughly chronological order.

Murray's system of needs

Murray (1938) published "Explorations in Personality", a book introducing his system describing personality in terms of needs. Murray claims that human nature involves a set of universal basic needs, with individual differences on these needs leading to the uniqueness of personality through varying dispositional tendencies for each need. He insists that specific needs are more important to some than to others and individual's differences of these needs lead to the uniqueness of a person's personality due to varying amounts of each need. Murray (1938) defines a need as a "potentiality or readiness to respond in a certain way under certain given circumstances" and puts needs in two levels: primary and secondary. Primary needs consist of any biological need, such as food, water, and oxygen, etc. Secondary needs are defined as needs that are generally psychological, for examples, nurturing, achievement, and independence. Murray identified a total of more than 17 needs, each belonging to one of five particular need categories: Ambition, Materialism, Power, Affection, and Information (Friedman and Schustack, 2012). He believes that each need is important in and of itself while he also thinks that needs can support other needs, conflict with one another, and be interrelated. Murray invented the term subsidation of needs when two or more needs are combined in order to satisfy a more powerful need and fusion of needs when a single action satisfies more than one need. Murray's theory has had a substantial influence on further human's needs study, personality testing and research although some critics feel that Murray's system of needs is too broad and rather subjective.

Maslow's hierarchy of needs

Maslow's hierarchy of needs is a theory in psychology proposed by Maslow (1943) in his seminal paper "A Theory of Human Motivation" in Psychological Review. Maslow coined the terms "physiological", "safety", "belongingness" and "love", "esteem", "self-actualization", and "self-transcendence" to describe the pattern that human motivations generally move through. Maslow's hierarchy of needs is often portrayed in the shape of a pyramid with the largest, most fundamental level of "physiological" needs at the bottom, followed by the "safety" needs, then followed by the needs in the middle, the "love/belonging" needs as the second from the top, and the needs for self-actualization and self-transcendence at the top.

The most basic and fundamental four layers/levels of the pyramid contain what Maslow (1943, 1954) called "deficiency needs" or "d-needs": physical, security, friendship and love, security, and esteem needs. He suggests that if these "deficiency needs" are not met, with the exception of the most fundamental (physiological) need, there may not be a physical indication, but the individual will feel anxious and tense. Maslow's theory asserts that before the individual strongly desires (or focuses motivation upon) the secondary or higher level needs the individual's most basic level of needs must be met first. Maslow also created the term "metamotivation" which is concerned with the motivation of people who go beyond the scope of the basic needs and strive for constant betterment.

Maslow recognizes that the human mind and brain are very complex and have parallel processes running at the same time, and therefore multi-fold, different motivations from various levels of the hierarchy can happen at the same time. Instead of stating that the individual focuses on a certain need at any given time, Maslow suggested that a certain need "dominates" the human organism. In other words, Maslow focuses on identifying the basic types of needs and motivation, and the order in which the needs should be met while recognizing that the different levels of motivation could occur at any time in the human mind.

Maslow's hierarchy contains five levels of basic needs. Beyond and above these needs, other or higher levels of needs exist, for examples, the needs for understanding, esthetic appreciation, and purely spiritual needs, etc.

Alderfer's ERG theory

Proposed by Alderfer (1969, 1972), ERG theory (Existence, Relatedness and Growth) is a theory further derived or modified from Maslow's hierarchy of needs model, by categorizing the five levels of hierarchy into three groups: Existence, Relatedness and Growth. In particular, Alderfer grouped the lower order needs (Physiological and Safety) into the Existence category, put Maslow's interpersonal love and esteem needs into the Relatedness category, and categorized the self-actualization and self-esteem needs into the Growth class. Similar to original classification of Maslow's hierarchy of needs model, the existence group deals with providing the basic material existence requirements of human beings, including the items considered to be physiological and safety needs by Maslow. The second category of needs is those of relatedness, the desires persons have for maintaining main or important interpersonal relationships. Relatedness group approximates or aligns well with Maslow's social need and the external component of Maslow's esteem classification. The relatedness or social and status desires necessitate interaction with other people. Alderfer considered growth needs as intrinsic desires for personal development, including the intrinsic component from Maslow's esteem category and the characteristics contained under self-actualization.

McClelland's learned needs theory

Developed by McClelland (1988), the Need theory (also known as Three Needs Theory or the Learned Needs Theory) is a motivational model which aims to explain how the needs for achievement, power, and affiliation affect the actions of people in a managerial context. This theory was actually developed in the 1960s after Maslow's hierarchy of needs model in the 1940s. McClelland suggests that individuals, irrespective of age, sex, race, or culture, have these three types of motivation and a person's motivation and effectiveness in certain job functions are impacted by these three needs. He states that the type of motivation by which each individual is driven derives from their life experiences and the opinions of their culture. More specifically, McClelland insists that an individual's specific needs are acquired over time and are shaped by one's life experiences. As a consequence, McClelland's theory sometimes is oftentimes referred understandably and justifiably to as acquired-needs theory or the learned needs theory. It is worthwhile to note that McClelland's theory allows for the shaping of a person's needs and therefore: training programs can be used to modify one's need profile; people with different needs are motivated differently; a person's needs may be changing/dynamic.

Max-Neef's fundamental human needs model

Human needs and human-scale development, proposed by Max-Neef et al. (1989a, 1989b), are seen as ontological (stemming from the condition of being human), are few, finite and classifiable, as distinct from the conventional notion of conventional economic "wants" that are infinite and insatiable. Max-Neef et al developed a taxonomy of human needs and a process by which communities can identify their "wealths" and "poverties" according to how their fundamental human needs are satisfied. Max-Neef et al. classifies the fundamental human needs as:

- subsistence
- Protection
- Affection

- Understanding
- Participation
- recreation (in the sense of leisure, time to reflect, or idleness)
- creation
- identity
- freedom

Needs are also defined according to the existential categories of

- Being
- Having
- Doing
- Interacting

And from these two dimensions, a 36 cell matrix is developed which can be filled with examples of satisfiers for those needs.

3. Human Roles and Actions

Because individuals have different levels of needs and wants as well as play many different roles in lives and they bear many different responsibilities, the individuals need to take all kinds of actions to meet the needs, and fulfil his duties. Let us take a manager as an example.

From a managerial context, Mintzberg (1971, 1973) studies the diverse and multi-faceted roles a manager has within an organization and further identifies and describes ten specific managerial roles most commonly seen within organizations. Each of these roles is defined as an organized collection of behaviors belonging to an identifiable position or function. He classifies the ten roles into three subcategories:

- Interpersonal Contact
 - Figurehead: performs ceremonial and symbolic duties as head of the organization
 - Leader: fosters a proper work atmosphere and motivates and develops subordinates
 - Liaison: develops and maintains a network of external contacts to gather information
- Information Processing
 - Never center (or Monitor): gathers internal and external information relevant to the organization
 - Disseminator: transmits factual and value based information to subordinates
 - Spokesperson: communicates to the outside world on performance and policies
- Decision Making
 - Entrepreneur: designs and initiates change in the organization
 - Disturbance handler: deals with unexpected events and operational breakdowns
 - Resources allocator: controls and authorizes the use of organizational resources
 - Negotiator: participates in negotiation activities with other organizations and individuals

In the real world, a manager may have many more roles to play and these and other roles can overlap and change over time and vary in different contexts and situations. A manager needs to learn how to balance them in a diligent manner in order to manage efficiently and effectively. Although a manager's work can be identified, described, and analyzed by these individual roles, they are undoubtedly intermixed and interdependent in practice.

Although not humans are managers in the managerial view per se, human beings may assume many different roles similar to the ones listed above for managers, in a different context (if not in addition to the managerial context). After all, an individual needs to manage his own life. The individual, in addition to a career/job, he would assume different roles at home, local community, membership in various association, clubs, and organizations. We would argue that at least the three categories (interpersonal contact, information processing, and decision making) can be readily applied to or adapted to the situations where individuals are involved or concerned with.

4. Virtual or Digital Assistants

Kasabov (1998) maintains that AI systems should exhibit the following characteristics:

- Accommodate new problem solving rules incrementally
- Adapt online and in real time
- Are able to analyze itself in terms of behavior, error and success.
- Learn and improve through interaction with the environment (embodiment)
- Learn quickly from large amounts of data
- Have memory-based exemplar storage and retrieval capacities
- Have parameters to represent short and long term memory, age, forgetting, etc.

Today's virtual or digital assistants can, to different degrees, some simple tasks that might have been performed by a personal assistant or secretary in the past. Some examples of the modest tasks may include looking up phone numbers, placing calls, taking dictation, reading text or email messages aloud, anticipating requests, and reminding the end user about appointments, etc. Virtual or digital assistants are programmed with artificial intelligence, machine learning, and some other technologies, such as voice recognition. As the end user interacts with his digital assistant, the AI programming may make use of sophisticated algorithms to learn from data input and become better at understanding and predicting the end user's needs. In the near future, virtual or digital assistants will be built with more advanced cognitive computing technologies that will allow a virtual or digital assistant to understand and carry out multi-step requests and perform more complex tasks (e.g., reserving an airplane ticket).

Although we are excited about the initial success of some the virtual or digital agents, we feel that virtual or digital assistants are still in the early development stage and the tasks they can perform are preliminary in nature and quite limited in number of applications. Along with general AI agents or artificial intelligence, major breakthroughs/developments are needed so that more meaningful and useful tasks can be performed before they can widely accepted and used by end users.

5. A Framework for Virtual or Digital Assistants

Humans have a wide range of needs and motivations. They play assume and play many different roles in lives and take all kinds of actions to live, survive, or thrive. Virtual or digital assistants have started to appear and can perform some simple tasks, with different degrees of success. But much is to be desired. Today's virtual or digital assistants or agents can mainly do some searching or help persons play some simple informational roles. Ideally, virtual or digital assistant, together with other AI agents, should provide meaningful assistance for the end users play roles in all aspects: informational, interpersonal, and decisional. Along with other roles, we think that virtual or digital agents would be desirable to have the following functions or capabilities:

- Searching
- Sensing
- Exploring
- Adapting
- Communicating
- Analyzing
- Solving
- Negotiating
- Deciding
- Learning
- Other actions

We propose a general framework for the development of virtual or digital assistants (See Figure 1). In the center is the triangle depicting the human needs or wants and motivations. Persons then need to play different roles and take plethora of actions to achieve their goals or fulfill their responsibilities. Virtual or digital assistants should gradually and incrementally gain the capabilities to help human beings in different kind of activities, such as searching, sensing, exploring, adapting, communicating, analyzing, solving, negotiating, deciding, learning, among other actions.

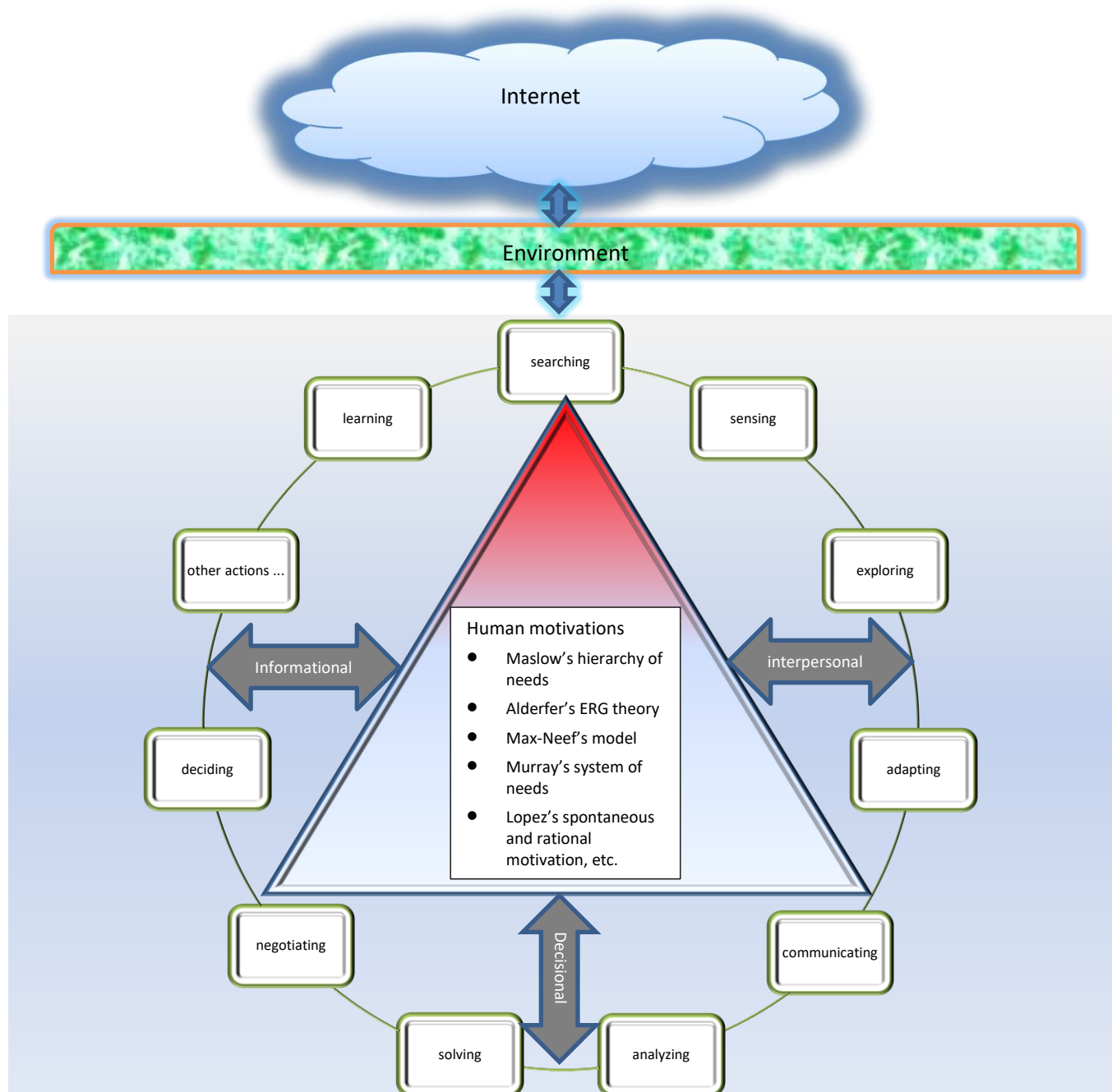


Figure 1: A framework of virtual assistants

The framework itself is exploratory and can certainly be further developed, enhanced, or modified. We did not include roles, or functions or capabilities for people with unique or special needs, for examples, functions or capabilities to aid or support activities for people with disabilities, with special living or working conditions, etc. We did not include discussions on user interface or usability issues. For example, while voice-activated virtual or digital assistants (with natural language processing capabilities) are the norm, we would think that other types of user interfaces such as text-based, touch, or motion and gesture would be desirable or needed in certain applications for some users.

We would like to point out that our framework is a bit future looking and ambitious. Even with AI agents, or Artificial Intelligence in general, we had experienced some setbacks in the past. Many of the functions and sub-functions cannot be supported by the current AI agents or software agents today. While we believe that some of the issues or barriers will be resolved or disappear as computing and communication technologies advance, other theoretical and practical issues will remain in the foreseeable future.

6. Discussions and Recommendations

Although the application of digital or virtual assistant is still in the early stage and the research in the area of virtual or digital assistant is in the formative stage, now is a good time to take stock of these efforts. We think that it is important and necessary to examine systematically what the current status is and make efforts to investigate where the new frontiers are likely to be even though we are a bit exploratory in both areas.

We attempt to develop a framework for virtual or digital assistant, mainly conceptually, trying to avoid mixing different levels of notions, from conceptual ideas, strategies, principles, guidelines, procedures, to operational steps. We are in the inceptive stage of AI agent development and use, not to mention virtual or digital agents that are even newer phenomenon. There is a very long and uncertain journey for us to travel. Our list of recommendations is not intended to be thorough or extensive but rather precursory and preliminary.

- Upgradable: virtual/digital assistant or artificial agent (program) should be upgradable like other software or AI agents
- Incremental: virtual or digital assistants should be able to accommodate new problem solving rules or add new functions incrementally
- Modular design: modules can be added and removed
- Adaptive: virtual or digital assistants should be able to adapt online and in real time to new environment/applications
- Learning: virtual or digital assistants should be able to learn and improve through interaction with the environment (embodiment) and learn quickly from large amounts of data
- Enterprise view instead of functional area view: To actively perform their functions, Intelligent Agents today are normally gathered in a hierarchical structure containing many “sub-agents”. Intelligent sub-agents process and perform lower level functions. Taken together, the intelligent agent and sub-agents create a complete system that can accomplish difficult tasks or goals with behaviors and responses that display a form of intelligence (Weiss, 2013). It is worthwhile to note that new modules created by or for the functions should not result in silo-effects and inconsistency.
- Security: We should not make the same mistake as we did with the development of the network of networks (i.e., the Internet) where security was an after-thought and take security into paramount considerations from the early stages. Otherwise we would face dire consequences because virtual or digital assistants will inevitably become more popular and intertwined with human lives and people will be more depend on them.
- Privacy: virtual or digital assistants should be developed and used in such a way that the users’ privacy be protected.
- Social: virtual or digital assistants should be developed and used in such a way that positive impacts be maximized and negative impacts be minimized or an ideal balance be stroked
- Legal: virtual or digital assistants should be developed and used in such a way that legal issued be well addressed
- Ethical: virtual or digital assistants should be developed and used ethically
- Standards/protocols: new standards or protocols should be developed so that AI agents or virtual or digital assistants can communicate and work with each other.

References

- Alderfer, Clayton P. (1969). An Empirical Test of a New Theory of Human Needs; *Organizational Behavior and Human Performance*, Vol. 4, No. 2, pp. 142–175.
- Alderfer, Clayton P. (1972). *Existence, Relatedness, and Growth: Human Needs in Organizational Settings*, New York: Free Press.
- Dover, M. A., and Joseph, B. H. R. (2008). Human needs: Overview. In T. Mizrahi & L. Davis (Eds.), *The encyclopedia of social work* (20th ed., pp. 398–406). New York, NY: Oxford University Press and National Association of Social Workers.
- Dover, M. A. (2015). Human needs: Overview. In C. Franklin (Ed.), *The encyclopedia of social work* (Electronic ed.). New York, NY: Oxford University Press and National Association of Social Workers.
- Franklin, S. and Graesser, A. (1996). Is it an Agent, or just a Program?: A Taxonomy for Autonomous Agents, in *Proceedings of the Third International Workshop on Agent Theories, Architectures, and Languages*, Springer-Verlag.
- Friedman, Howard S. and Schustack, Miriam W. (2012). *Personality: Classic Theories and Modern Research*. Pearson Allyn & Bacon.
- Kasabov, N. (1998). Introduction: Hybrid intelligent adaptive systems. *International Journal of Intelligent Systems*, Vol.6, pp. 453–454.
- Maslow, A.H. (1943). A theory of human motivation. *Psychological Review*. Vol. 50, No. 4, pp. 370–96.
- Maslow, A.H. (1954). *Motivation and Personality*. New York, NY: Harper.
- Max-Neef, Manfred A., Elizalde, A. and Hopenhayn, M. (1989a). Human scale development: conception, application and further reflections. New York: Apex. Chpt. 2. Development and Human Needs, p. 18.
- Max-Neef, Manfred A., Elizalde, A. and Hopenhayn, M. with the cooperation of Felipe Herrera, Hugo Zemelman, Jorge Jatobá, Luis Weinstein (1989b). *Human Scale Development: An Option for the Future*. Development Dialogue: A Journal of International Development Cooperation. 1, pp. 7-80.
- McClelland, D. (1988). *Human Motivation*. Cambridge University Press.
- Mintzberg, Henry (1971). Managerial Work: Analysis from Observation. *Management Science*, Vol. 18, No. 2, Application Series. (Oct., 1971), pp. B97-B110.
- Mintzberg, Henry (1973). *The Nature of Managerial Work*. New York, NY: Harper & Row.
- Murray, Henry A. (1938). *Explorations in personality*. New York, NY: Oxford University Press.
- Russell, Stuart J. and Norvig, Peter (2003). *Artificial Intelligence: A Modern Approach* (2nd ed.). Upper Saddle River, NJ: Prentice Hall.
- Russell, Stuart J. and Norvig, Peter (2009). *Artificial Intelligence: A Modern Approach* (3rd ed.). Upper Saddle River, NJ: Prentice Hall.
- Weiss, G. (2013). *Multiagent systems* (2nd ed.). Cambridge, MA: The MIT Press.