The Spacetime Perspective on AI-assisted Decision Making

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Abstract. We consider human decisions as shaped by five P’s: People, Principle, Policy, Process and Practice. We examine and characterize three continua in terms of the five P’s: (1) the natural continuum from particle to transcendental system where human species (people) is the major component, (2) the hardware-software continuum from bit to complex computer application created by humans (people), and (3) human decision spacetime as “E⁴={rational, non-rational, irrational, time} → problem identification and investigation → solution” in which human (people) decisions govern and move their creations such as business, market and economy. We use analogy and analogical reasoning among components of the continua to formulate automation for AI-assisted decision making.

1. Five P’s of business: People, Principle, Policy, Process and Practice
Decisions and actions are entities that move business and government from a point A to point B, e.g. one situation to another. For business and government environments, we consider decisions as shaped by the five P’s as shown in Figure 1. Each P is complex in its own right. The P in the middle (People) creates and affects all other P’s and itself.

Figure 1. The five P’s

People is the most intelligent and most important entity of the environment in which they live and work. People identify principles that they draw from nature and life, adopt them, observe them, and experience them. A simple principle is “common sense”. Another simple but highly difficult principle to observe is “ethics” which passively guides human behavior. People create policies (e.g. rule, regulation, law, etc. in policy making) as norm or guidance to scope their decisions. One simple policy on financial derivatives is the cap on futures and options trading in Baring Bank Singapore [1]. People develop processes (including planning) and models to arrive at their decisions and actions. They build theories and devise methods such as those found in Management Science/Operations Research or
Business Analytics. They exercise best practices (execution) for business growth and profit. For the most part, the P’s in business are grossly flat and linear in descriptive, prescriptive and predictive modeling.

1.1. Problematic P’s

Note that four of the five P’s, Principle, Policy, Process and Practice, commonly exist in corporate and government documents. They aim at expressing full rationality (plain reason/logic and data-driven), however, at times, rationality is not fully observed. It can be highly influenced by non-rationality and irrationality [2]. The non-rationality or irrationality occur due to a number of reasons. One of which is the disrespect to one or more of the other P’s by the first (People) resulting in anomalies. Signs and symptoms of anomalies might be hidden, covered up, undetectable, and unpredictable [3] [4].

Examples of corporate fiascos’ undetected anomalies caused by decision making in business institutions are: People can turn bad due to greed or other reasons (e.g. Nicholas Leeson, GM of Barings Bank Singapore played the Martingale game and exhausted the Bank’s assets in 1995). Principles may not be observed or are intentionally ignored (e.g. leverage level of Lehman Brothers reached 40 to 1 resulted in huge debt, low rating and insufficient cash flow). Policies may be narrow, incomplete or intentionally violated and Processes may be ill-defined or intentionally skipped (e.g. Andrew Fastow, CFO of Enron violated the 3% independent investment rule in thousands of special purpose entities). Practices may be badly executed or intentionally abused (e.g. the subprime lending market went uncontrollably due to NINJA loans (No Income No Job or Asset). These have resulted in corporate fiascos leading to market turmoil and economic meltdown as we have experienced in 2008 [5].

1.2. Incomplete reforms

Many previous and major corporate fiasco such as Barings Bank, Enron and Lehman Brothers have been largely and carefully investigated, e.g. for why and how they happened, e.g. violations and issues on the P’s and lessons learned. They were well discussed in the literature [6] [7] [8].

They have resulted in reforms which have been proposed for future corporate fiasco avoidance or prevention purpose. For example, after Enron and MCI WorldCom, at the policy level, we had Sarbanes-Oxley Act (SOX) in 2002 and after Lehman Brothers, Dodd-Frank Act in 2009. Ethics in institution became a hot issue in the literature and business schools. However, debacles caused by fiascos kept reoccurring. After Barings Bank’s collapse in 1995, another rogue trader of Societe Generale, Jerome Kerviel, single-handedly lost some $7 billion in 2008 in practically the same fashion. After SOX, Freddie Mac committed accounting fraud in 2003. Reforms in terms of policy, process and practice appear insufficient. In addition, at times, the decisions on corporate fiascos appear arbitrary, e.g. both Bear Stearns and AIG, were bailed out by the Fed and US Treasury but Lehman Brothers was not. In fact, there is current effort to repeal Dodd-Frank Act.

2. Approaches to decision making

Traditional decision making under uncertainty and under risk is based on probability theory, utility theory, expected utility theory, and recently prospect theory [9], and other methods in disciplines such as MS/OR [2]. Two characteristics of prior theories are observed: the domain is the set $D$ of relevant decisions to be mapped to $[0, 1]$, and the goal is optimization.

Herbert Simon gave an account of rational decisions and decision making methods and a plethora of diverse treatments which were called theories of the firms, including his own. He differentiated three categories of decisions: rational, non-rational and irrational. Since then, in the 1980’s and 1990’s, there has been effort to account for the role of emotion and intuition (irrational and non-rational) in decisions under risk and uncertainty. In the 2000’s, decision making became the subject of neuroscience research [10], cognitive science [11], cognitive neuroscience [12]. Neuroeconomics was introduced [13]. Kahneman formalized decision making in his Thinking Fast and Slow, and which argued the linkage between neuroscience to psychology [14].
Note that in theory and practice, we have been taught in textbooks and best practices to follow the following general decision model: “Euclidian problem space $E^3$ over time $E^1$ as in $E^3 \times E^1 \rightarrow$ linear decision alternatives $\rightarrow$ solution” for deliberation on a choice to be selected. In this model, the thinking process is actually effective on a narrowly defined problem since it involves only a small collection of alternatives. However, a selected decision is good only in the problem space identified or scoped. Its impact to other problems spaces (lager, smaller or different from or relevant to the original problem space) is of limited understanding where it might be relevant or unpredictable.

To overcome at least the above issues and maybe others, we propose to reverse the problem space model sketched in the previous paragraph. We look at a decision continuum space in which everything is subject to consideration and investigation: a thought, a sign, a symptom, a problem, a decision, a solution, etc. as in “decision spacetime ($E^4=$rational, non-rational, irrational, time) $\rightarrow$ problem identification and investigation $\rightarrow$ solution”, where decision spacetime is scoped and defined analogously to Minkowsky-Riemann-Einstein spacetime [15] sketched in Figure 2 below. Thus, in spacetime jargon, a decision is an event, thinking is light, and a thought is the occurrence of a flash light. A thought involves neurological as well as psychological involving the P’s. We claim that decisions could be looked at in decision spacetime.

![Figure 2. Decision spacetime](image)

3. **Characterizing decision spacetime**

3.1 **Decision cone**

The first insight is that a decision made is similar to a mass dropped on the surface of water in a pond. It creates the circular effect which ripples through time (Figure 3.A). It is seen as a cone (Figure 3.B). In this way, the decision cone is similar to the light cone in Minkowski’s environment, in which human thought is the flash light traveling through spacetime.

With the light cone concept, there are the future cone (the upper cone of Figure 3.C) and past cone (lower cone). The light travels within the light cone is called worldlines (at the speed less than speed of light), on the surface of the cone is spacelines (at the speed of light) and outside is timelines (at speed higher than the speed of light). The connection between the past cone and future cone illustrates a causal relationship. Nothing can pass from inside to outside area. Such a jump is an anomaly or singularity.

In the decision analogy, the past cone houses past decisions, and the future cone the consequence and impact, and future decisions. Different than the light cone concept, the human thought process as decision making can go from inside to outside. It is because a thought is a networked neurons where the synapses can intertwine in an unpredictable manner, specifically it can involve from rationality (prefrontal cortex) to irrationality (emotion, limbic system) or non-rationality (intuition, gut feeling). Human intention, desire, greed, ambition, etc. can be well hidden in their decision’s spacetime, unreachable by anyone. This would offer an explanation on why Nicholas Leeson of Barings Bank, Andrew Fastow of Enron and Richard Fuld of Lehman Brothers committed fraudulent acts.
3.2 Decision curvature
We argue that a critical decision is similar to a heavy mass creating a curvature (Figure 3.D) in decision spacetime similar to how the sun creates a gravitational curvature, around which the earth and other planets are orbiting. The curvature of a heavy or critical decision affects other decisions. Decisions can be the matter expressed as mass \( m \) (or force or energy). It implies that we can express, analogously, the decision (e.g. matter) tells the institution, market or economy (entities in decision spacetime) how to curve, and the institution, market and economy tells decision how to move.

![Figure 3. Decision in spacetime and curvature](image)

3.3 Decision impact
The cone will introduce a quadratic term similar to \( \Delta e = (dx^2 + dty^2 + dz^2 - cdt^2) \) called Minkowski interval (where \( c \) is the speed of light) as opposed to the linear distance (difference) of all decision probabilities used in decision science for decision making. When \( c=1 \), it is equivalent to a decision having no action (equivalent to a Newtonian free fall). The closer a particular institution\( N \) (Figure 3.B) is to the point of reference of decision\( 1 \) (institution\( 1 \)) the stronger and the faster the impact affecting it from decision\( 1 \) in the future cone. Another insight is that we need to watch and measure the combined effect in the collection of different decisions affecting the current one (decision\( 1 \)) in the past cone. The above discussion suggest two measures: Minkowski interval and combined measure of decision impact.

4. Analogy and analogical reasoning for potential AI processes and algorithms

![Figure 4. The biological spectrum/hierarchy](image)
4.1. Human decisions from biological spectrum perspective

Placing decision spacetime in the natural continuum where any entity occurs suggests that there are analogies among different components of von Bertalanffy-Boulding’s biological spectrum/hierarchy [16] [17] from protoplasm to biosystem (Figure 4). The analogies must be there since all components are part of the hierarchy. The human brain is an aggregate of lower components (particles, cells, brain tissues, etc.) whereas the mind is capable of creating abstract concept such as institution (a kind of community), market (a kind of ecosystem) and economy (a kind of biosystem). Decisions are made by the human brain/mind. Furthermore, the human component is to maintain balance (constancy in cell, homeostasis in human, stability in institution, equilibrium in market or balance in economy) and control in the other P’s it creates. It implies that any deviations from balance and control would expose the signs and symptoms of anomalies in decisions made by humans (people).

4.2. The P’s by analogy and analogical reasoning

First, we identify three core principles underlying the balance and control of each component: its environment, goal and control: (1) Environment in which each component lives and works, e.g. cells (Cells box of Figure 5) are in the milieu interieur (internal environment) [18], humans of institutions are in the data environment (Humans box), institutions are in the information environment (Institutions box), markets are in the product environment (Market box), and economy in the financial environment (economy), (2) Goals to be achieved by each environment (in each of the above boxes), e.g. constancy in cells, homeostasis in humans [19], stability in institutions, equilibrium in markets and balance in economy, and (3) Control to be exercised by each component, e.g. Ashby’s molecular cybernetics in cell component [20], Wiener’s cybernetics in humans [21], Beer’s managerial cybernetics in institutions [22], Grubstrom’s market cybernetics [23], and Hoffman’s economic cybernetics [24].

Second, we recognize the analogous organizations among components: either hierarchical, networked or both. These organizations exist in the human body, human brain, in institutions, market and economy. And, third, the analogy between operations in each of the component involving their supporting entities, e.g. DNA in cells is analogous to internal biochemical and electrical rule in human body, corporate policy in institution, regulation and law in market and economics. Below is an analogy example between cancer in human and fiasco in institution in terms of fiascos.

When abnormal cells in the body grow uncontrollably, they exist as tumor. The tumor can turn malignant and can proliferate to other organs and affect the homeostasis of human body. By the time cancer is discovered it is in later phase, and possibly causes death. The autonomic nervous system (ANS) is aware of most of what is going on with cancer cells. However ANS could not detect cancer cells for a couple of reasons and it does not report to human conscience. One of the reasons, for example, is that the cancer cells have on their membrane a special protein which makes them look like friends rather than foes to the white cells. Analogously, in an institution, we might have one employee and/or a group of employees who turn greedy. They can grow uncontrollably. They cover up their decisions to commit fraud. By the time top management is aware of what is going on, it is too late.

The first insight from the above analogy is that, based on the fact that ANS does not have complete knowledge of cancer and does not report to higher level, we want our institution to be more than the ANS-equivalent functionality. We want our model to have a Management by Exceptions (MBE), which can fully detect and report anomalies and singularities. It means we have to look at decision spacetime, and build an MBE or rebuild an existing one, which can do more than data mining from our data warehouse. This is to assist higher management in spotting anomalies hidden, covered up or undetectable by the current IT applications.

4.3. AI applications

We can look at human decisions in its human decision continuum (darkened triangular area) as it interacts with the two continua as shown in Figure 5. The natural continuum (top thick bar, from particle to transcendental system) which the biological spectrum is a part of (detailed in Figure 4) offers an understanding on how human decisions are made from neurological perspective (low level) in the brain.
to the psychological perspective (high level) in the mind. Human decisions create everything in the *hardware-software continuum* (bottom thick bar, from bit to complex applications, AI included). We postulate that humans must have been patterning their decisions after the autonomous processes in the biological spectrum components, and implementing them on the hard-ware-software continuum.

![Diagram of three continua](Figure 5. The three continua)

The above argument and example attempt to illustrate, from a curved spacetime perspective, the *why* and *how* a corporate fiasco may occur as the results of disrespect to the P’s for the purpose of prevention. Our general scheme to address the AI-assisted solution is as follows.

- **Ability to recognize anomalies in situation perception of critical signs and symptoms.** In Barings case, executives and top management missed all the signs of Nicholas Leeson being in a path to destruction because the only thing they saw was the bonus. There is a need to increase monitoring and reporting capability of the signs and symptoms of anomalies by technological advances to enhance human shortcomin

- **Ability to measure decision impact using Minkowski interval as metric, beyond the narrowly defined problem space with a set of alternative D.** We extend the set D of singleton decisions with corresponding measure to the σ-field \( D, 2^D, m \) on D with Dempster-Shafer’s belief measure \( m \), where \( 2^D \) is the powerset of D, where the rule of combination can be exercised. The above gives a suitable scope for developing formulas, equations, algorithms for potential AI applications.

- **Consideration on long-term decision impact to subsequent consequences in curved spacetime.** People tend to formulate immediate or short-term reactions to perceived or reasoned consequences (therefore flat). Long-term consequences are in curved spacetime, more difficult to detect or predict them. In Enron case, it was the complexity of SPE structural and functional organization, in addition to the double role of Arthur Anderson, both auditing and consulting (a violation of policy), which blinded the process and practice.

5. **Concluding remarks**

We have presented in this paper a collection of systemic concepts and a sketch towards addressing critical decisions from a preventive perspective, differently from traditional approaches: (1) descriptive, (2) prescriptive, and (3) predictive. Two disciplines, healthcare and criminology, and recently cyber security, are probably more advanced and more developed than business and management disciplines, in terms of prevention involving the five P’s: people, principles, policy, process and practice. In fact, healthcare has seen an abundant of medical research and development. So are criminology and cybersecurity. We thought lessons could be learned from reviewing the above disciplines for potential analogy, where applicable, among their five P’s and ours. After all these disciplines all belong to the two continua (natural continuum and hard-ware-software continuum). From the spacetime perspective, AI-assisted decisional algorithms for prevention will be further detailed. This is a work-in-progress, far from reaching its end. We ask for the indulgence of readers and we seek feedback on the validity of the proposed concepts and descriptive sketch of prevention for further development.
References

[1] Leeson, Nicholas. 2012. *Rogue Trader*, Little Brown Book Group.
[2] Simon, H. 1979. Rational Decision Making in Business Organizations, *The American Economic Review*, Vol. 69, No. 4 (Sep. 1979)
[3] Ketz, J. E. 2003. *Hidden Financial Risk: Understanding Off-Balance Sheet Accounting*, Wiley, 2003.
[4] Le Maux, J. and Morin, D. 2011. “Black and White and Red All Over: Lehman Brothers’ Inevitable Bankruptcy splashed across its Financial Statements”. *International Journal of Business and Social Sciences*, Vol 2, No. 20.
[5] Shell, A. 2015. “Lehman Bros. collapse triggered economic turmoil”, http://abcnews.go.com/Business/lehman-bros-collapse-triggered-economic-turmoil/story?id=8543352
[6] Powers, W. Jr. 2002. Report of Investigation, http://i.cnn.net/cnn/2002/LAW/02/02/enron.report/powers.report.pdf
[7] Dharan, B. and Rapoport N. (Eds). 2009. *Enron and Other Corporate Fiascos*, Foundation Press.
[8] Kirkpatrick, G. 2009. “The Corporate Governance Lessons from the Financial Crisis”. Financial Market Trends, OECD, Vol. 1
[9] Kahneman D. and Tversky, A. 1979. A Prospect Theory: An Analysis of Decision under Risk. *Econometrica*, 47(2).
[10] Damasio, A. 2005. *Descartes’ Error: Emotion, Reason and the Human Brain*. Penguin Book.
[11] Frydman. 2016. The Psychology and Neuroscience of Financial Decision Making, *Trends in Cognitive Science*. DOI: https://doi.org/10.1016/j.tics.2016.07.003, 2016
[12] Naqvi, N., Shiv, B. and Bechara, A. 2006. The Role of Emotion in Decision Making: A Cognitive Neuroscience Perspective, *Current Directions in Psychological Science*, Vol. 15, No. 5. 2006.
[13] Glimcher P.W. Camerer C.F., Fehr, E. and Poldrack R. A. 2013. *Neuroeconomics: Decision Making and the Brain*. Elsevier.
[14] Kahneman D. 2011. *Thinking Fast and Slow*. Farrar, Strauss and Giroux.
[15] Chappell, J. M., Hartnett, J. M., Chappell, J. G., Hartnett, N., Iqbal , A. and Abbott, D. 2016. *Exploring the origin of Minkowski spacetime*, https://arxiv.org/pdf/1501.04857.pdf
[16] von Bertalanffy, L.V. (1950). An Outline of General System Theory, http://www.isnature.org/Events/2009/Summer/t/Bertalanffy1950-GST_Outline_SELECT.pdf
[17] Boulding, K. E. 1956. “General System Theory – The Skeleton of Science” in *Management Science*, Vol 2, No. 2.
[18] Gross, C. G. 1996. “Claude Bernard and the constancy of the internal environment”, *Neuroscientist* 4 (1)
[19] Cannon, W. 1963. *The wisdom of the body*, The Norton Library, Norton & Company
[20] Ashby, W. R. 1957. *An Introduction to Cybernetics*, Chapman and Hall LTD.
[21] Wiener, N. 1948. *Cybernetics or Control and Communication in the animal and the machine*, The Technology Press.
[22] Beer, A. 1995. Brain of the Firm, 2e. Classic Beer Series. ISBN: 978-0-471-94839-1.
[23] Grubstrom, R. 1969. *Market Cybernetics Processes*, Stockholm, Almqvist & Wiksell.
[24] Hoffman, R. 2010. “A Cybernetic Approach to Economics”, in *Cybernetics and Human Knowing*. Vol 17, no. 4
[25] Nguyen, T. 2014. A Different Approach to Information Management by Exceptions: Towards Bankruptcy Prevention, *Information & Management*, 51 (Issue 1)
[26] Nguyen, T. 2016. *Preventing Corporate Fiascos: A Systemic Approach*, Palgrave MacMillan.