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Learning and Usability of Accounting Information Visualization

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Abstract

Visual representations for concepts in business management are quite challenging, especially those abstract concepts in Accountancy discipline. For example, there might not be a consensus on what to use to represent such abstraction as an asset, liability, or owner equity. This is because asset can be property, estate, resources, equipment, or any tangible or non-tangible valuables. Cognitive science concepts and behavior engagement have been used to develop visual representations for financial data. The concepts include spatial processing, big picture thinking, and metaphor. Review of past studies together with a brief research plan to test the usability for learning of four new augmented reality 0visuals are provided in the present paper.

Keywords : Financial Data, Accounting Information Visualization, Augmented Reality, Usability for Learning

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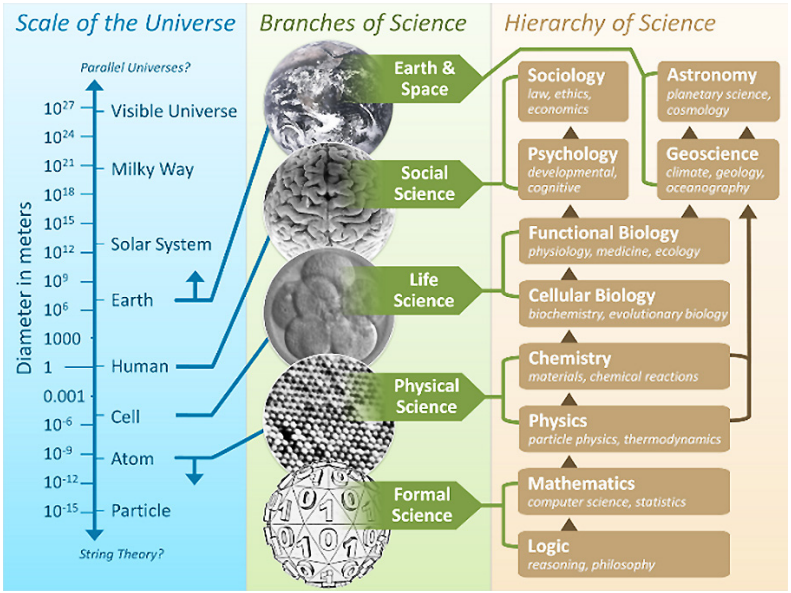
1. Introduction

Inscription and pictograph are conceivably known as an early form of information visualization. From primitive configurations of symbols and shapes to representations of physical objects and abstractions, mankind's thirst of visual representations as a means of communication has extended to all branches of science, physical science (Earth and Space), social science, life science, physical science, and formal science (<Figure 1> depicted by Eric Fisk (Efbrazil) on 12 April 2013). Scientific visuals resemble physical, observable objects. In scientific visualization, the challenge of analyzing georeferenced data (i.e., Universal Transverse Mercator (UTM) coordinates between latitude and longitude of earth surface) has been addressed with respect to its big data nature [Griffith, 2013]. The massive amount of data being collected posts an even more difficult task for scientists and statisticians to transform the data into understandable visuals and meaningful interpretation [Tufte, 2001].

"While related fields such as scientific visualization involve the presentation of data that has some physical or geometric correspondence, information visualization centers on abstract information without such correspondences, i.e., information that cannot be mapped into the physical world in most cases" ([Kerren and Schreiber, 2014], p. 176). Once the scientific community took on to information visualization, researchers and practitioners in social science especially those users of financial data have followed the trail closely. To harness the power of human visual perception and cognition, social scientists rely on scientific metaphor to visualize the intangibility of the abstractions in their own field.



〈Figure 1〉 Branches and Hierarchy of Science by Efbrazil (https://commons.wikimedia.org/wiki/File:The_Scientific_Universe.png)

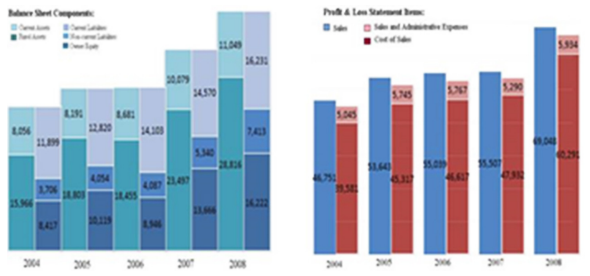
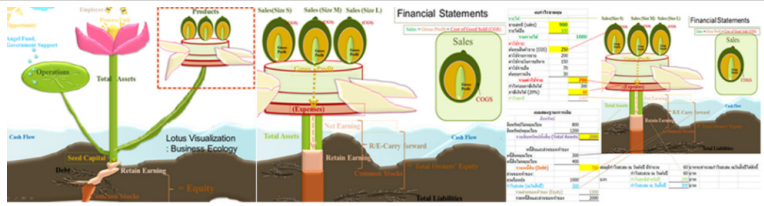
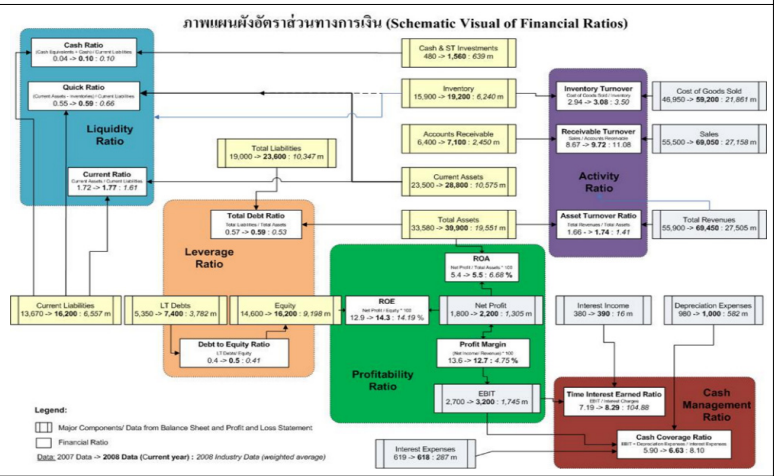
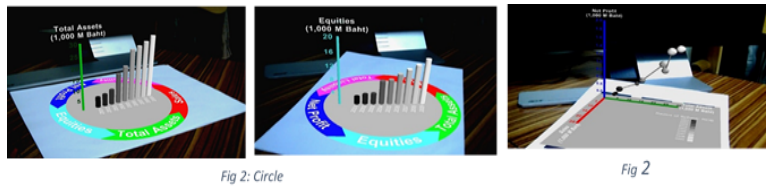
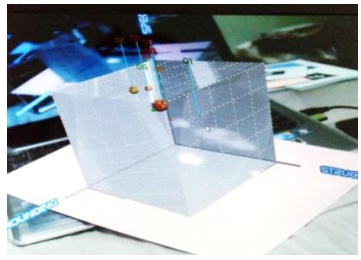
2. Accounting and Financial Information Visualization

Although the field of information visualization has focused on and came up with creative and intuitive approaches to convey abstract information, the visual representations of financial data still rely on typical geometry modeling graphs despite the lack of spatial coordinates of financial data. As Tegarden [1999] pointed out almost two decades ago, business decision makers have learned to treat business diagrams such as tables, outline, pie charts, line graphs and bar charts as "natural" metaphor for business visualization [Tanlamai and Tangsiri, 2012]. However, the author encouraged information visualization designers to extend their quest to deal with multidimensional nature of business data. The author also provided several examples of visual representations such as Kiviat diagram (radar chart or spider graph), Parallel coordinates (popular in the area of visual data mining), 3D Scatter gram (available in statistical packages), 3D Line graph (representing 4 measures), Volume rendering (from scientific visualization technique), Floors and walls (using room metaphor), Maps (natural, geographical representations), and Surfaces (appropriate for continuous data variables) [Dull and Tegarden, 1999].

Visual representations for concepts in business management, accounting discipline in particular, are quite challenging [Tanlamai, 2009]. For example, there might not be a consensus on what to use to represent such abstraction as an asset, liability, or owner equity. This is because asset can be property, estate, resources, equipment, or any tangible or non-tangible valuables. Some accounting and financial data are inherently spatial with geographical location (i.e., GIS coordinates). Also, these data are often collected and kept as time series data with various attributes and dimensions. While historical and up-to date financial data are important for performance management, live feeds data such as stock tick data (often shown as candlestick chart) are critical to an investor's decision. Thus, the design and use of accounting information visualization should not only address the visual and spatial skills of humans, allowing a person to recognize patterns, color and shape, as well as motion.

The advancement of information visualization technology has provided opportunities for new and effective design of accounting and finance visualization. Dilla et al. [2010] reviewed visualization of financial reporting and auditing context and indicated companies offering services from using financial market data visualization (i.e., Smartmoney's^{TM} Map of the Market FinViz^{TM}, and various Financial Networks companies) and pointed out the research of Chang et al. [2008] who reported the use of interactive visual analysis to detect fraud from financial wire transactions by large financial institutions [Chang et al., 2008; Dilla et al., 2010]. Business Intelligence and Visual analytics tools such as Tableau, Microstrategy, Qlikview, etc. have long included popular graphs such as Heat maps, Treemaps, and Small multiples, Bullet graphs, Symbol maps, Filled maps, Box-and-whisker plot, etc. into their software packages. These

〈Table 1〉 Finance and Accounting Information Visualization (1)

Accounting Data	Accounting Information Visualization	
- Statement of Financial Position - Income statement - Cash flow statement - Financial Ratios	Balance sheet visualization (Symbolic versus Spatial tasks) [Tanlamai and Soongswang, 2011]	
	Plant Metaphor visuals (Nature Metaphor) [Rungpaka et al., 2012]	
	Big picture visuals (data network and flow) [Tanlamai and Tangsiri, 2012]	
	AR-circle and line, cube [Tanlamai et al., 2011; Tanlamai et al., 2012a]	
	[Tanlamai et al., 2012b]	

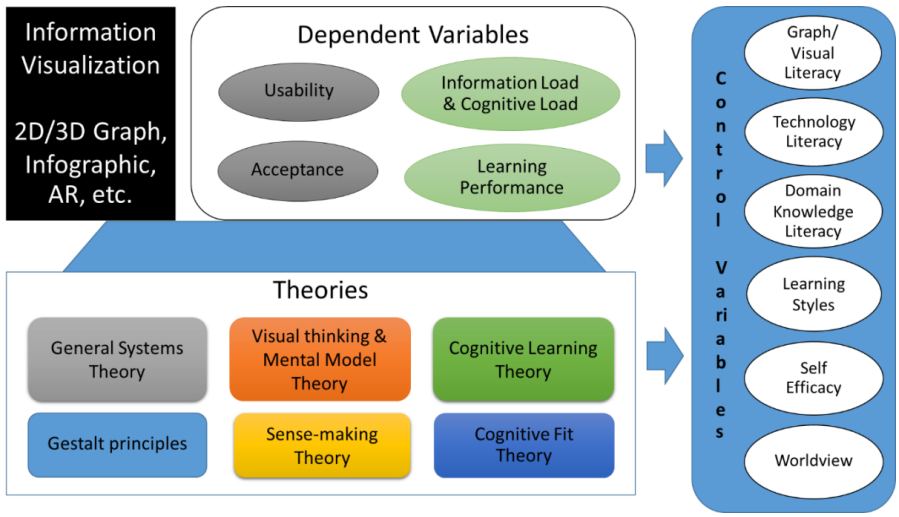
visuals are inevitably shown up in the boardrooms of large corporations. However, Hierarchical tree and hyperbolic tree diagrams are still yet to work their way to top management's arena. Nevertheless, they have spread contagiously in social network analytics and technology related domains [Chen and Yang, 2010; Pirolli et al., 2003]. Appendix A shows some of these selected scientific information visualizations that might be applicable for accounting data. Accounting information visualization researchers may want to explore these visuals further.

<Table 1> shows the earlier work from the author and associates on accounting information visualization. These visuals were developed and used in research quests, mainly on whether they are usable, acceptable and insightful; how they will reduce cognitive load, elevate higher learning level and achieve learning performance. Spatial representations of balance sheet and profit and loss statements were designed to give a quick glance of major components in the statements [Tanlamai and Soongswang, 2011]. Plant metaphor was used to represent the ecosystem of various data elements of a financial statement [Rungpaka et al., 2012]. Again, the visual representation was developed on the premise that viewers can easily comprehend the relationships between data elements in question. Likewise, big picture visual scheme was designed to see the whole system, its subsystems and their relationships as in data network or document flow diagram [Tanlamai and Tangsiri, 2010, 2012].

Originally two AR visuals, circle and line, were developed and used in the experimental study to assess the cognitive load and learning outcome of students. Tanlamai et al. [2011] conducted a within-subject experimental study using 58 undergraduate accounting students to compare the user's learning experience of traditional Excel tables of numbers versus AR FinViz developed for financial accounting data [Tanlamai et al., 2011]. The results showed that AR outperformed tables in almost all cases. Also, students using AR were able to assess the firm's financial performance similar to that of the experts. Later the **cube** were added to compare various accounting data of companies within the same industry [Tanlamai et al., 2012b]. Each ball represents certain accounting data (e.g., assets, sales, and profits) of a company and the size and color of the ball indicates the sign and magnitude of performance.

3. Learning and Usability of Accounting Information Visualization

Previous studies are based on different theories and their corresponding dependent and control variables. <Figure 2> summarizes the constructs used in the studies by author and associates in the past many years. The main independent variable has always been different accounting information visuals as shown in <Table 1>. Control variables such as learning style [Felder and Solomon, 1998], self-efficacy, and various types of literacies are included. Existing research employs independent variables that compare traditional visualization such as symbolic accounting data in EXCEL tables and



〈Figure 2〉 Theories and Variables Under Studied

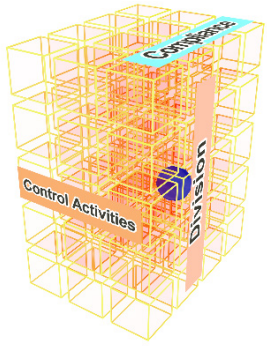
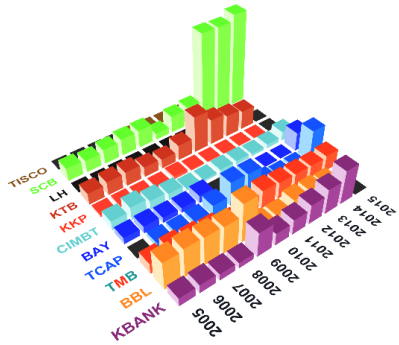
graphs with alternative visuals such as spatial graphs and accounting information visuals as shown in <Table 1>. Although some of the findings are inconclusive, what seems to be consistent is that users of accounting data prefer to mixed symbolic and spatial graphs; they found AR visuals to be interesting, useful and acceptable. However, these AR visuals do not increase their learning performance nor do they reduce the cognitive load of the users.

4. Development of Accounting Visualizations Using AR Technology

One of the most difficult tasks for visual development is to be the master of the domain knowledge of which one want visualize [Lemieux et al., 2014]. Four accounting related topics were included in the development of new visuals : CSR (Corporate Social Responsibility), audit risks, Enterprise Risk Management (ERM), and financial statement analyses. They are chosen because hardly any information representations have been found on CSR and audit risks and even though there are numerous visual representations for ERM and financial statement analysis charts, the existing visualizations can be improved by enhancing a more natural way if interaction.

In the area of **CSR (Corporate Social Responsibility)**, previous research tended to focus on reviewing disclosure of CSR information with benchmarking of CSR reports in various countries [Lock and Seele, 2015; Yeshmin, 2012]. None have examined the graphic representations nor any information visualization of CSR data. For **audit risk** visualization, previous academic and professional have presented the concept using table and geography modeling graphics. Also, the majority of information representations employ flowcharts to visualize compliance and audit processes [Bellamy et al., 2007; Eppler and Aeschimann 2009; Silveira et al., 2010]. There are plenty of COSO ERM re-

〈Table 2〉 Interactive Finance and Accounting Information Visualization - with AR technology

Accounting Data	Accounting Information Visualization -AR Technology	Representation model
CSR		Adapting from "*Floor and Wall*" metaphor with Circular view comparing 3 different aspects of CSR, including Economic, Social and Environment.
Audit Risk Management		Animated visual showing audit risk model used to do an audit plan. In order to determine the Planned Detection Risk (PDR), Acceptable Audit Risk (AAR), the Inherent Risk (IR), Control Risk (CR), and will be assessed.
COSO		The COSO ERM comprises 60 sub-cubes that are the combination of 5 components of internal control, 4 level of operations, and 3 types of objectives. Each sub-cube represents 17 principles and 2 evaluation processes, making a total number of 2,040 audit issues.
Financial statements		Comparison of time-series accounting data items in financial statements from each corporation (banks and security firms) are represented with "*Floor and Wall*" metaphor in order to resemble *the peak and valley of* "*Surface*" visualization as much as possible.

search and the **COSO ERM Framework** together with the Risk Assessment Model (Risk Matrix or Risk Map) are perhaps the most used and redrawn pictures. COSO ERM information cube is one of the most classic representations of accounting information visualization. Finally, the most mundane information visualization of accounting figures is EXCEL generated charts (i.e., column, bar, line, and pie charts) of **financial statements.**

Augmented Reality has been chosen as the key visualizing technology because once the representation is used, the learners may be able to develop better cognition, perception, sense-making, and reasoning. The purpose of these AR representations is more of a descriptive diagram then as a call-to-action diagram. Users/learners are expected to find these newly developed information representations of the four accounting related topics to be usable and provide higher levels of learning [Bloom, 1956]. Funded by the academic affair of a large public university and designed by Larngear Technology (www.larngeartech.com), <Table 2> shows the newly developed accounting information visualization. These AR visuals will be tested for their usability for learning these accounting topics. Think aloud technique of collecting data from purposive sampling will be used. Again Cognitive Learning Theory will be the basis for the upcoming studies. An e-book that incorporates these AR visuals will be also developed.

The author believes that interacting with AR visuals should come naturally by learners because AR technology can integrate digital information with the user's environment in real time. Learners uses their own existing environment and overlay augmented reality visuals on top of it. The visual mappings of a learner starts with encode the representation. Then he/she can reconfigure the axes by manipulate the markers to get different views of data. The aforementioned interaction technique is expected to increase the comprehension of the large amount of underlying accounting data.

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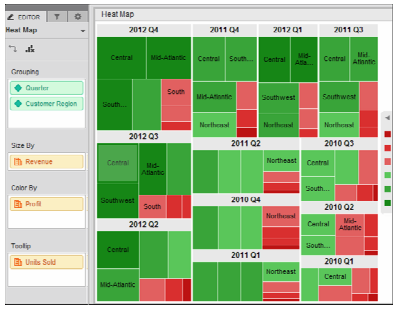
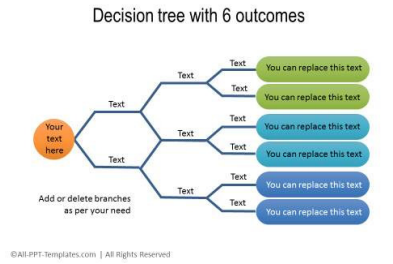
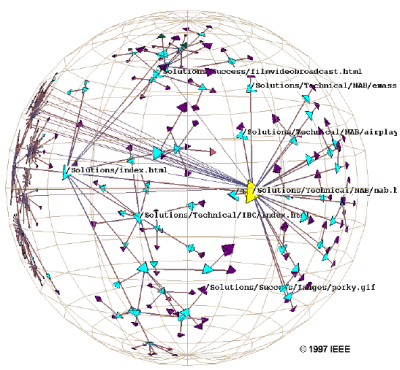
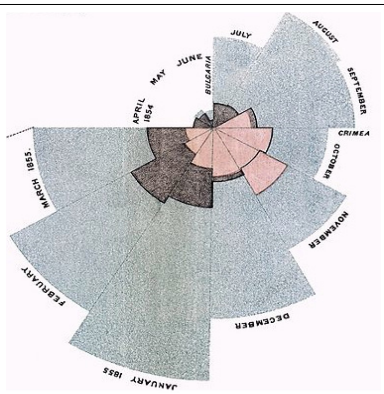
<Appendix A>

Selected Scientific Information Visualizations Adapted from Tegarden [1999] and Dilla et al. [2010]

Visuals	Description	Example Visuals
Heat map	This graphical representation depicts the individual data values in a matrix with different colors and magnitude information. Financial related representations include data of market capitalization, segmental financial performance, Risk map-probability and impact. For market capitalization application, the treemap can provide information in 3 hierarchical levels : the entire market, market sectors, and industries.	
Hierarchical tree diagram	This is one of the most commonly used methods in cluster analysis. The diagram provides effective visual condensation of the clustering results.	
Hyperbolic tree [Bach, 2016; Pirolli et al., 2003]	This type of tree employs hyperbolic space that has more room than Euclidean space in presenting data. By using radius of a circle, the tree will be less cluttered when trying to include many parents and nodes together. Financial related applications include social network transactions, navigation of financial data, and perhaps corporate ownership structure.	
Rose diagram [Allaby and Allaby, 1999.]	A circular histogram plot which displays directional data and the frequency of each class. Originated with Nightingale's presentation of her mortality statistics of soldiers dying from infectious diseases, rose diagram has been used for example data such as wind direction, ocean current direction, and so on. Closely related to rose diagram is the EXCEL's radar chart or spider diagram.	

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