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Integrating the GOMS Model and the Intelligence Cycle

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Abstract: This paper considers the Goals, Operators, Methods, and Selection (GOMS) model of tasking within the context of the intelligence cycle. Integrating these concepts may provide a foundation for better understanding the actions that occur within the individual stages of the intelligence cycle. Given these notions, four perspectives are considered: (1) intelligence producers, (2) intelligence consumers, (3) the virtual environment, and (4) the intelligence cycle. This paper provides conclusions and recommendations for research involving the integrating of the GOMS model with variants of the intelligence cycle among government and commercial settings. Practical use and value may be found among many fields, ranging from business analytics to homeland security.

Key words: business analytics, GOMS, intelligence analysis, intelligence cycle, homeland security
JEL codes: M10, L89, Y80

1. Introduction

Intelligence analysis involves gathering, assessing, analyzing, reporting, disseminating, and using information regarding some situation or scenario via the intelligence cycle. More specifically, a traditional view of the intelligence cycle commences with a determination of needs and proceeds through intermediary stages of obtaining, organizing, and analyzing the acquired information (Murphy, 2005). The intelligence cycle concludes with the stages of deriving conclusions, generating recommendations, and disseminating materials to relevant users (Murphy, 2005).

Within the context of business organizations, business intelligence is a relevant aspect of crafting strategy and enhancing competitiveness (Fleisher & Bensoussan, 2015). In such instances, views of the intelligence cycle incorporate the phases of various forms of analysis, gaining insights, contemplating actions, and various measurements for the purposes of evaluation (Phythian, 2013; Vercellis, 2009). Perspectives of business organizations incorporate the use of various electronic technologies and resources, such as data mining and online analytical processing (OLAP) tools, as processing mechanisms whereby intelligence products are generated to

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support the rendering of human decisions (Li & Lin, 2014).

The practical aspects of intelligence permeate the public safety domain. For instance, radiometric resources may be used to screen earthen levees to determine where weaknesses exist within their infrastructures (Aanstoos et al., 2011). Within the contexts of emergency management and homeland security, if levee weaknesses are identified and rectified, then the harmful effects of disasters may either be averted or mitigated. Open source intelligence items consist of numerous resources that are available publicly. For instance, various open source resources may be used to gather intelligence and to evaluate the potential of certain terrorist groups to affect American society (Wigginton et al., 2015). Intelligence is also used to generate threat matrices whereby localities may enhance the crafting of strategic emergency plans (McElreath et al., 2014b).

Intelligence activities encompass a variety of endeavors ranging from collecting and organizing observations to the ultimate generating of a product that influences the rendering of a human decision regarding a course of action within a problem domain. Examples include polling, analyzing media broadcasts, using database products, analyzing images and networks, intercepting and analyzing electronic communication, and data processing for economic analysis (Treverton & Gabbard, 2008). Although intelligence activities are human endeavors, they incorporate the use of electronic technologies (ranging from mobile devices to desktop machines). Using such electronic devices often necessitates a human-machine relationship involving a virtual environment.

This relationship, between human and machine, is within the domain of human-computer interaction. Humans perform numerous activities among virtual environments ranging from the use of analytical software tools to the use of multi-media presentation resources. The use of such products encompasses the notions of accomplishing a goal, performing some type of operation, the appropriate methods of accomplishing the intended goal, and rendering decisions regarding the completion of the intended activity. These notions are exhibited within the GOMS model of human-computer interaction.

Within the intelligence cycle, every activity involving any interaction with some type of computerized and electronic device necessitates a consideration of the GOMS concept. Whether it is the entering of observations into a database system or the electronic dissemination of an intelligence product, the foundational four concepts of GOMS are present within the human-machine relationship. Further, this relationship may be considered from four perspectives: (1) producers of intelligence, (2) consumers of intelligence, (3) the virtual environment, and (4) the intelligence cycle. Given these considerations, this paper briefly introduces and considers the GOMS concept within the context of intelligence analysis.

2. Components of the Generic Intelligence Cycle

The intelligence cycle is a multi-stage, iterative model that commences with the phase of recognizing of a problem and the culminating phase of leveraging an information product to influence the rendering of a human decision. Mathematically, the intelligence cycle represents a reflexive entity whose phases may be repeated as necessary through time. The basic model of the intelligence cycle consists of the following states: (1) planning and direction; (2) collection; (3) processing; (4) analysis and production; and (5) dissemination. The following table highlights the salient attributes of each stage of the intelligence cycle.

Table 1 Intelligence Cycle Stages

Stages	Brief Descriptions
Planning/Direction	The managing of the cumulative effort, from the identification of data needs to the delivering of intelligence products to consumers product to a consumer (FAS, 2012).
Collection	The collecting of necessary information (raw form) for producing completed intelligence entities (FAS, 2012).
Processing	The converting analytically of collected information to some form that is useful for humans (FAS, 2012).
Analysis/Production	The generating of completed intelligence analytically via processes of integration, evaluation, and analysis of the gathered data toward the preparation of an intelligence product (FAS, 2012). The gathered data may have integrity issues ranging from completeness to contradiction (FAS, 2012).
Dissemination	The disseminating of completed, final intelligence products to the necessary users (FAS, 2012).

3. The Original GOMS Model

The characteristics of the basic Goals, Operators, Methods, and Selection (GOMS) model are given as follows:

- Goals — Goals are symbolic structures defining some desired attainments and specifies the methods whereby they may be possibly achieved (Card, Moran, & Newell, 1983).
- Operators — Operators are actions, involving cognitive, perceptual, or motor skills, whose executing is a necessity for changing the attributes of mental states or for affecting the environments in which tasks are performed (Card, Moran, & Newell, 1983).
- Methods — Methods are descriptions of procedures that are necessary for accomplishing goals and are useful for storing knowledge (Card, Moran, & Newell, 1983).
- Selection Rules — Selection rules are the basis of selecting the method(s) through which goals may be attempted (Card, Moran, & Newell, 1983).

4. Characteristics of the Intelligence Cycle and the GOMS Model

Within the virtual environments associated with the intelligence cycle, humans must complete tasks to attain various goals as a component of accomplishing tasks within the virtual domain. The goals and tasks that comprise these activities may be direct components of an endeavor (e.g., database queries) or may be indirect components (e.g., database administration). The basic definitions of each component of the GOMS model are applicable when considering such activities.

Goals within the virtual setting may encompass the completion of background checks of suspected offenders; the submission of an intelligence report electronically; the completion of a virtual questionnaire; the use of crime mapping software to generate relationships among target entities; etc. Operators within the virtual setting may encompass using a mouse or a keyboard, interacting via virtual video resources; configuring and implementing a user interface; etc. Methods within the virtual setting may encompass instructions stated within a software instruction manual; adhering to the instructions of a given activity; the operating instructions for accessing and managing newsgroups; the use of video, auditory, or textual resources within the virtual environment; etc. Selection rules within the virtual setting may involve choosing from multiple methods of input, output, or interaction within the virtual environment; determining the appropriate recipients of an intelligence product; and the dissemination processes and procedures, etc.

Tasks associated with the virtual environment may vary while encompassing a myriad of activities. Examples include managing virtual mailing lists; participating in virtual conferencing (video, audio, and text); uploading and downloading files; sending and receiving documents; performing case study simulations; and implementing word processing, database, spreadsheet, statistical, analytical, and mapping tools. The attributes of interaction within the virtual environment become salient considerations when considering the goals concepts associated with the intelligence cycle. The operational aspect of generating intelligence products combines both cognitive and motor skills through an interface linking humans with the virtual environment.

During this period of integration between humans and the virtual environment, humans must follow some form of methodology to complete activities involved with generating intelligence products. Various and sundry rules, policies, and procedures may govern the content and participation requirements associated with generating intelligence. Given these descriptions, it is evident that intelligence activities within the virtual environment involve the foundational components of the original GOMS model during their completion.

The intelligence cycle is a relatively straightforward paradigm for supporting human decisions via the collecting and processing of data. Derived from McElreath et al. (2013) and Murphy (2005), its cyclical phases are as follows: (1) acknowledging some issue requiring attentiveness using intelligence; (2) determination of intelligence requirements; (3) intelligence acquisition; (4) intelligence organization; (5) intelligence analysis; (6) generation of an intelligence product; (7) dissemination of and intelligence product; and (8) rendering of a human decision using the intelligence product.

Intelligence cycle outcomes are related to the resources, materials, and processes that are involved with generating products (Jensen, McElreath, & Graves, 2013). Humans must acknowledge and identify circumstances that contribute toward the generating of an intelligence product. Collecting and organizing observations may involve various facets of data entry and database systems. During analysis, the use of statistical hypothesis testing may be necessary to determine whether differences exist among groups or to determine whether a potential strength of relationship exists between examined target entities. Drawing conclusions necessitates an interpretation of the findings that result from analytical testing. Making recommendations results from examining the presented conclusions. The rendering of a human decision results from contemplating the given recommendations, and accepting or rejecting courses of actions.

Depending on the type of intelligence activity, a variety of tasks may necessitate human interaction within the virtual environment. For instance, within the context of law enforcement, virtual training courses and regimens may be undertaken that involve various goals, methods, rules, and anticipated outcomes (McElreath et al., 2013). From the perspective of justice system communication, various electronic communication systems are used to transmit and receive messages between humans (Doss, Glover, Goza, & Wigginton, 2015). Humans should proficiently, effectively, and demonstrably exhibit a satisfactory knowledge of how to accomplish any desired endeavors in order to successfully generate an intelligence product within the virtual domain. Once this product is available, it must be disseminated and contemplated before human decisions are rendered.

Given these considerations, the foundational GOMS concepts are applicable. Essentially, some type of goal exists within the intelligence cycle, such as the successful rendering of a human decision that involves the use of a final intelligence product. Operators may consist of using image processing software or some type of statistical tool. Methods may consist of a specific analytical method, such as regression or other form of statistical analysis. Selection rules may accommodate the courses of actions that are possible, such as delineations of best case, probable case, and worst case venues.

The generating of an intelligence product often involves interaction among factions of producers, consumers, and the virtual environment. Given this notion, four perspectives of GOMS and the intelligence cycle are identified: (1) producers; (2) consumers; (3) virtual environment; and (4) intelligence cycle. Participants within the virtual environment may be producers or consumers of the derived intelligence product. The virtual environment itself involves an imaginary setting created from the integration of the analyst, consumer, and intelligence resources necessary for the generating of a product. Therefore, the integration of GOMS within the intelligence cycle may be witnessed and experienced differently from each of these perspectives.

Any number of decisions may be considered by the users of intelligence products. Within the context of policing and law enforcement, one area involves intelligence and hot spots of criminality. Using this example, the following tables show various perspectives of GOMS within the context of the law enforcement domain. The following table shows brief descriptions of the producer perspective:

Table 2 Producer Perspective Characteristics

Categories	Descriptions
Goals	Generate a report detailing relationships among crime hot spots within an urban environment with respect to a decision regarding the increasing of uniformed patrols.
Operators	Presence and availability of departmental crime mapping software to analyze and depict the hot spot relationships.
Methods	Use crime mapping software with appropriate pattern matching algorithms.
Selection	Generate and disseminate report contributing to the rendering of a human patrol decision.

The following table shows brief descriptions of the consumer perspective:

Table 3 Consumer Perspective Characteristics

Categories	Descriptions
Goals	Receive a report detailing relationships among crime hot spots within an urban environment with respect to a decision regarding the increasing of uniformed patrols.
Operators	Presence and availability of departmental intelligence resources.
Methods	Use appropriate personnel and resources (physical and virtual).
Selection	Receive disseminated report contributing to the rendering of a human patrol decision.

The following table shows brief descriptions of the virtual perspective:

Table 4 Virtual Perspective Characteristics

Categories	Descriptions
Goals	Act as an overall process domain space between human-machine systems to generate reports detailing relationships, perhaps among crime hot spots within an urban environment, with respect to a decision regarding increases of uniformed patrols.
Operators	Instantiating and crafting the existence and availability of an intermediary nexus and domain space between humans and machines. Examples of operational resources include crime mapping software, pattern-matching software, etc.
Methods	Exercising the intermediary nexus and domain space between human-machine systems. An example includes using crime mapping software to show hot spots of criminality and drawing conclusions based on the findings of the crime analysis.
Selection	Decision alternatives regarding the intelligence report and its conclusions. An example is the decision to increase, maintain, or reduce investigative efforts.

The following table shows brief descriptions of the cyclical perspective:

Table 5 Intelligence Cycle Characteristics

Categories	Descriptions
Goals	Generating of an intelligence report that contributes toward the rendering of a specific human decision.
Operators	Presence and availability of departmental intelligence resources (both physical and virtual), including producers, consumers, and intermediaries.
Methods	Identified ways of integrating appropriate producers, consumers, and intermediaries.
Selection	Choosing the method of generating and disseminating a report contributing to the rendering of a human decision.

Although they represent different perspectives regarding an intelligence domain space, these four perspectives have a common characteristic: GOMS. Each of the four perspectives exhibits goals, operators, methods, and selections. Although it originated within the discipline of human-computer interaction, the concept of GOMS is not constrained to any one perspective or domain. Given these notions, the GOMS concept may be considered from the perspectives of portability and adaptability.

5. Portability and Adaptability for Practical Use

Although its initial considerations originated in computer science, its foundations (i.e., goals, operators, methods, and selection) extend beyond the computing disciplines. John and Kieras (1996) introduce various derivatives of the GOMS model, and indicate that they originate at high levels of abstraction. From a perspective of human-computer interaction, these levels of abstraction provide a basis for concealing much of the complexity that exists within human-machine systems. Because of such abstraction, the GOMS model has potential within the context of cognitive modeling (Olson & Olson, 1990). Given these notions, the GOMS model may be considered from the perspective of domains that are unrelated to human-computer interaction.

The basic GOMS concept exhibits some portability and adaptability across a variety of perspectives. Examples range from GOMS perspectives in electronic governance to contexts of gerontology. From the perspective of electronic governance, Din (2015) examines tasks involving the use of government web sites by citizens with respect to evaluating and comparing the usability of interfaces among user accounts. From the perspective of education, Doss and Sullivan (2006) consider GOMS with respect to learning outcomes and Bloom’s Taxonomy. Within the context of gerontology, Shiao (2014) examines GOMS from the perspective of short-term auditory memories. Allen, McElreath, Henley, & Doss (2014) examine GOMS from the perspective of virtual training and public safety education. Within the context of psychology, Jastrzembski and Charness (2007) examine GOMS with respect to elderly individuals and age-related performance regarding mobile telephones. Given these discussions, some evidence exists to suggest that GOMS may be portable among a variety of domains. Thus, some literary evidence exists to pose the notion that GOMS may also be ported and adapted within the context of the intelligence domain.

Any number of applications integrating GOMS and the intelligence cycle are imaginable. From the commercial perspective, data mining of big data sets necessitates the use of analytical techniques that merge GOMS and intelligence. During the 2010s, big data analysis was identified as one of the most substantial technological trends (Chen, Chiang, & Storey, 2012). Specifically, it involves the parsing of massive data sets that require unique and advanced analytical methods for storing, managing, analyzing, and visualizing data and the relationships contained therein (Chen, Chiang, & Storey, 2012). Generally, such data sets exceed the processing capacity of typically available software tools (Manovich, 2011).

Examples are relatively familiar. For instance, Yahoo, which experiences billions of daily transactions originating from 500 million monthly users, decomposes its Internet presence into categorical data entities for analysis (O'Leary, 2013). Similarly, Flickr, a popular social media image repository, contains billions of photographs for which such techniques are appropriate (Manovich, 2011). Additional pursuits include mapping of terrain and minefields for warfighting as well as mapping of the moon's surface (McElreath et al., 2014a). Natural disasters may be examined via the processing of image data whereby emergency responses may be better understood (Gokaraju, Turlapaty, Doss, King, & Younan, 2015). Practical use is also found within the context of forensic accounting in which data mining is useful for examining historical accounting data (Pearson & Singleton, 2008). Various geographic services, such as MapQuest, also possess mass data sets for which such analytical methods are necessary (Shekhar, Feiner, & Aref, 2015).

Integrating GOMS with the intelligence cycle provides some considerations of human decisions within these domains. For instance, in the contexts of Internet search engines, service provides may parse and analyze large data sets via the intelligence cycle toward fulfilling an overall goal of better understanding its users. In doing so, decisions regarding the Internet interface may be considered to provide user experiences that contribute toward generating faster, targeted search responses. In the case of terrain and geography, use of the intelligence cycle may occur to facilitate achieving the goals of traversing along a certain course, and generating recommended stops and amenities that exist along the route. As a result, users are better informed and may improve their ability to render decisions.

6. Conclusions and Recommendations

This paper introduces basic GOMS derivations within the context of the intelligence cycle and its analytical components. It is beyond the scope of this composition to present a research design and experiment to quantitatively analyze these derivations, their components, or any aspect of impacts regarding efficiency and effectiveness within the intelligence cycle. It is also beyond the scope of this research to quantitatively investigate any characteristics of participants, resources, or the virtual environment itself. Instead, this paper is concerned only with proposing concepts that may be catalysts for future research and are ancillary discussions to support the existing writings regarding GOMS and intelligence analysis.

During modern times, much of intelligence analysis involves virtual environments. The discussions herein show potential derivations of the foundational GOMS tenets regarding these virtual environments. These derivations encompass four different perspectives within the context of intelligence analysis: (1) intelligence producers, (2) intelligence consumers, (3) the virtual environment, and (4) the intelligence cycle. The foundational GOMS concept permeates each of the four perspectives.

This composition is merely a cursory introduction to the potential of GOMS foundations within the context of intelligence analysis. However, for future studies, it is recommended that the notion of whether the implementation of GOMS activities promotes positive intelligence outcomes with respect the anticipated products of intelligence endeavors. Therefore, it is recommended that the following research questions be investigated:

- Can the basic framework and architecture of the GOMS model be adapted within the context of the intelligence domain to generate a new model that is applicable for intelligence purposes?
- Does the implementing of GOMS activities promote the desired intelligence outcome(s)?
- What roles do intelligence producers play in stimulating GOMS relationships between people and human-machine systems throughout the intelligence cycle?

- What roles do intelligence consumers play in stimulating GOMS relationships between people and human-machine systems throughout the intelligence cycle?
- What roles do intelligence intermediaries play in stimulating GOMS relationships between people and human-machine systems throughout the intelligence cycle?
- What role does GOMS play in stimulating relationships between people and human-machine systems throughout the intelligence cycle?

Although these questions are pertinent for any generic instance of the intelligence cycle and GOMS, they also may be applied toward specific versions of the intelligence cycle among domains. For instance, the intelligence cycle used by government organizations differs somewhat from the intelligence cycle found among commercial organizations. Additionally, among commercial environments, various proprietary versions of the intelligence cycle exist, such as the version used by Microsoft (Pythian, 2013). Thus, the integrating of GOMS and the intelligence cycle may be examined from a variety of perspectives.

Practical value considerations are pertinent for a variety of disciplines, ranging from homeland security and emergency management to various applications within the commercial and government sectors. Future research endeavors may examine the usefulness of the GOMS constructs introduced herein toward improving the efficiency and effectiveness of rendering human decisions among such domains.

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