Concept of the *Time* and *Space* in Area Studies

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1. Area Studies and Area Informatics

When we consider *area informatics* as new paradigm, that would enable informatics to provide area studies with new approaches and knowledge, two approaches can be considered. The first approach is to learn the various aspects of *movements* of the area in terms of understanding the complex nature of humanosphere[1] with human behavior and to utilize informatics effectively as a tool for understanding *movements*, as well as in researching geographic information systems (GIS) and remote sensing (RS). The second involves more diversified approaches on informatics fields, in which its science expands extensively using diverse arrays of advanced or specialized information sciences and technological research which depends on the development of informatics, such as manipulating the big data, artificial intelligence (AI), or ontology-oriented studies for analyzing and predicting *movements.* It is noteworthy that this paper does not seek to answer the question of what an exactly area study is, as no clear definition is available currently. Accordingly, in this paper, area studies are understood as reading various aspects of *movements* which are observed in the area.

Meanwhile, both visible and invisible *movements* exist within the area that can decipher the various aspects of *movements* in the area. Further, we must fully consider these types of *movements* by grasping the relationships and connections between visible and invisible *movements*. Documents and data related to the area, various events and incidents occurring in the area, and people's words and behaviors are *visible movements.* In other words, these can be considered as the set of the event. However, it is difficult to see or understand what peoples' thoughts or intensions in each event and how to act for the forthcoming event in general. Therefore, such *movements* that are deep within are referred to as *invisible movements.* From the viewpoint of area studies, it can be said that deciphering the various aspects of areas are in fact an act of deciphering such *invisible movements* as well as *visible movements.* Regarding information science, its research subjects generally address *visible movements.* The meaning of information is understood similarly by everyone; hence, the objectivity and universality of data are preserved, and the results of various analyses must be reversible. Provided that one focuses on area studies, one conducts an area analysis using ICT, based on the premise of the abovementioned *visible movements.* This has been utilized to provide a basis for verifying hypotheses in areas such as anthropology, sociology, economics, and politics. Our current work does not deny the aspect thereof; however, we aim to acquire informatics that can decipher the *invisible movements* across the area. In other words, we are attempting to understand how *invisible movements* can be regarded as *visible movements.* Further, it is necessary to consider a process that can bring them into the world of informatics.

First, how can we handle information on *visible movements* to explore *invisible movements* in the area? Let us consider events and phenomena occurring in an area (hereinafter collectively referred to as events). We can expect that an event independently occurring in an area cannot occur by itself. There are circumstances and factors leading to the occurrence of the event, causing either direct or indirect human actions or reactions. This, in turn, leads to the next event. Deciphering movements in the area is tied together with an invariable index that is common to a series of movements, with the relationships and degrees of the movements becoming clear. Further, if an invariable index exists, what is it? In other words, even independently occurring events can be tied together by an invariable index and linked to each other to enable an association between related events and between actions and reactions. In other words, invisible movements might be estimated as those association of visible movements on the invariable index. If area dynamism is included in the complicated association with the in variable index of multiple occurrences, then it might be possible to use those associations to obtain new knowledge or new finding as specific *rule* or *regulation* not known before and to perform relative comparisons.

[1]Humanosphere is a word describing the area and space needed for the survival of us humans with human living environment [see http://www.rish.kyoto-u.ac.jp/Manga/Manga_Vol.1_en.pdf]

2. *Time*/*Space* Element and Area-Event Mapping Model

The common indicators of events in the area are *time* and *space*. It is clear that time elements and spatial elements are always included for all events occurring on Earth. For historical events, there are cases that the time and place of an event may not be known or may not be clear. However, as far as the event itself is concerned, even if the time and place are ambiguous or is still yet to be discovered, the event still contains time and space elements.

Next, to understand *invisible movements*, fragmentary *visible movements* were placed in the context of a four-dimensional world such that *invisible movements* accompanying new discoveries can be depicted. In other words, for example as shown in the study of the ancient East–West corridor in mainland Southeast Asia later, a technique can conceivably restore an event into the time-space's four dimensions of location(latitude and longitude), elevation, and time, or explore circumstances, factors, and effects of an event. In general, as for descripting historical events, the concepts of historical events feature six elements: event name, time, location, person, cause, and evidence.

For the descriptions and presentations of events focusing on areas (hereinafter also referred to as area-event), the literature does not only cover historical documents. In addition to documents, and along with map data, image data, and sound data, knowledge based on field research and listening data (hereinafter referred to as area information) are knowledge bases for elucidating area-events. In particular, to elucidate areal events, an area-event mapping model (described later) that was proposed when advocating for area informatics, along with the frameworks of *state* t*ransition* and *mapping* s*pace* will be introduced and externalized. In other words, it is necessary to become knowledgeable of these concepts. This is because in the observation and analysis of regions within area studies, natural phenomena, social organizations, politics, economics, and culture in the area are received, and the behavior of humans acting on the transitions across space and time. In other words, it is necessary to consider the comprehensive dynamism of movement. In addition, the representation of movements must be scientific and reproducible.

Here, it is necessary for the area-event to consider the attributes of the event. The event's attribute can be represented by the element 5W1H. In other words, event E_i can be represented accordingly.

$$E_i = \{ C_i, P_i, T_i, L_i, M_i, R_i \}$$

Equation 1

The attributes are as follows. C_i: content, P_i: people/organizations, T_i: time, L_i: location/ position, M_i: method/means, R_i: reason. Further, i = 1, 2,..., n, and $T_i > 0$. Here, T_i and L are attributes that can be considered as common terms, which correspond to the invariable index mentioned above, in all events. In other words, by mapping every event onto space–time, it is possible to observe the causes, influences, and circumstances of each event, as well as the correlation between the events. Additionally, it may be possible to elucidate a picture of a given region. In proposing area informatics, this concept was defined as an area-event mapping model as follows. This model is shown in Figure 1.

$$E_i=\{ C_i, L_i, E_v | U_g, T_i\}$$

Equation 2

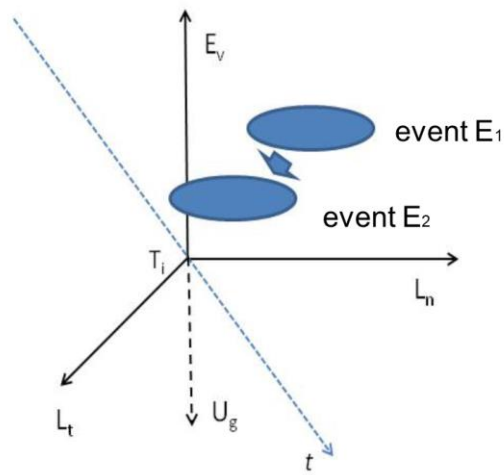


Figure 1: Area-Event Mapping Model

The event E_i is first assigned a position by the element L_i. The position at this point is considered as the latitude, longitude, and elevation in a three-dimensional space. Mapping is performed by adding the element T_i to this. That is, in Figure 1, the element L_i is represented by latitude L_t, longitude L_n, elevation E_v,, and finally time T_i, that is on the time axis t. Thus, the event E_1 is positioned in a four-dimensional space. For example, if T_i is the same, the events are mapped as events E_1, E_2, and so on. Arrows in the figure indicate cases where a relationship between events exists.

In clarifying the region, the author believes that events do not merely exist on the surface, but rather exhibit a deep connection with structures that exist below the surface level. Further, it is necessary to consider both the surface and subsurface structures comprehensively. For example, ground subsidence occurring over the course of years will cause

flooding and the sinking of houses, and directly affect people's daily lives. U_g as shown in Figure 1 implies considering the underground structure with respect to the elevation of the land. In addition, in the model shown in Equation 2, the elements P_i, M_i, R_i of Equation 1 are treated as being implicitly included. However, it is incomplete to acquire the knowledge of area-events to present them, and it is necessary to describe all elements explicitly.

Because the abovementioned area-event mapping model is incomplete from the viewpoint of knowledge acquisition and descriptions of area and historical events, in addition to the aforementioned six elements, the concepts of state transition and mapping space are also required. Details of this discussion will be omitted herein (see Shibayama, 2009).

3. Three-Dimensional Time-Space Model

In the area-event mapping model, it is shown that a movement in an area is to be understood as an *event* that is expressed in a four-dimensional space and then described. Meanwhile, a three-dimensional time-space model exists that understands events in the area as being able to be expressed by a set of three elements: *subject*, *time* value, and *spatial* value, thus positioning area studies as a research resource and as one subject (Kubo et al., 2010). Here, *subject* refers to research fields and themes such as meteorology, agriculture, economics, politics, and society. In addition, one event is small scale, and it is mapped to both events by considering a set of events associated with other events and other research fields and themes, i.e., archives that are expressed on the macro scale. Based on this model, Hara and Sekino map *time* and *subject* elements using the visualization tool "HuTime" (Sekino, 2010) and map the *spatial* and *subject* elements using the visualization tool "HuMap" (Kubo et al, 2010) developed for those purposes. HuTime and HuMap are important tools for describing *events* involving visible movements in a region (Figure 2).

4. Case Study - Historical Transition in Mainland Southeast Asia

Let us first consider how the archaeological sites were expanded from prehistoric and prehistoric times to the Ayutthaya period in the 18th century as one of cases in the mainland Southeast Asia referencing with the area-event mapping model.

As shown in Figure 3, the center of Dvaravati (6-11 centuries) was made up by U Thong in Suphanburi, Nakhon Pathom on the coast very close to U Thong, Khu Bua in Ratchaburi, Lopburi, Si Mahosot in Prachinburi, and one theory suggests that it originated in U Thong. If they connect these regions geospatially, it can be seen that they are located along an arc running northwards from Khu Bua on the western side of the Chao Phraya basin, across Nakhon Pathom and U Thong in the north, Lopburi in the northeast, and Si Mahosot in the southeast and flourished. These cities are described as the ancient port-cities, which means all the cities were once located along with the shoreline.

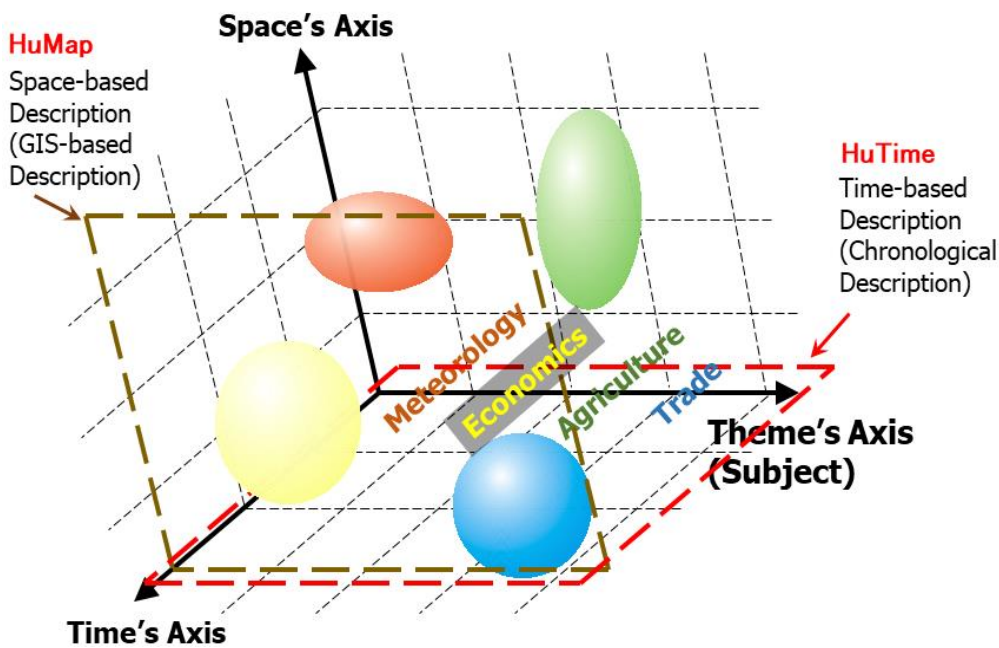
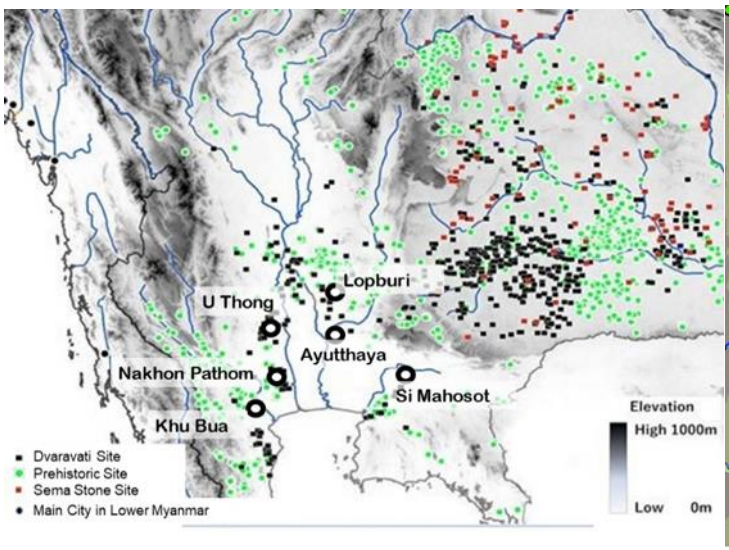
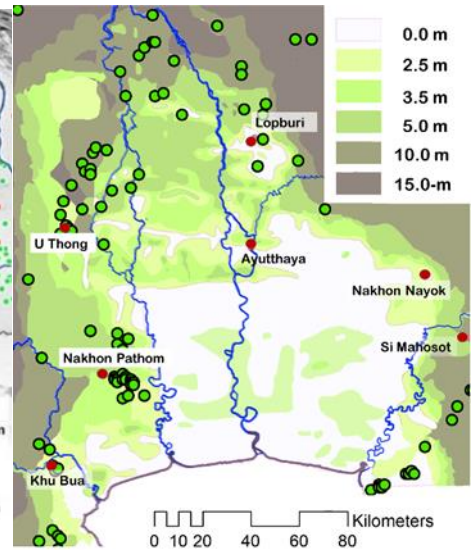


Figure 2: Three-Dimensional Time-Space Model
Source: [Kubo, M., Hara, S. and Sekino, T. 2010]



(a) Around BC.5-11 Century



(b) 6-11 Century (Dvaravati Period)

Figure 3: The Archaeological Sites in the Ancient Period

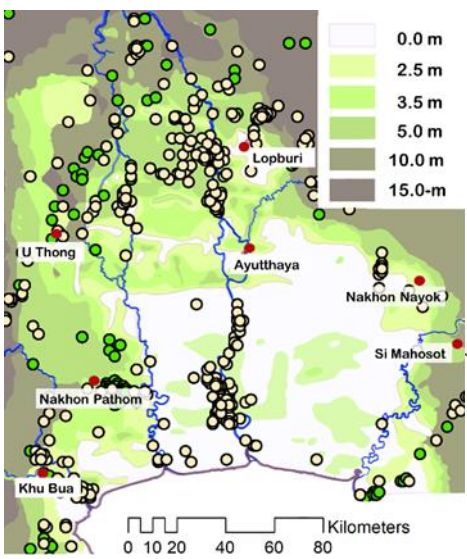


Figure 4: Dvaravati and Ayutthaya Period

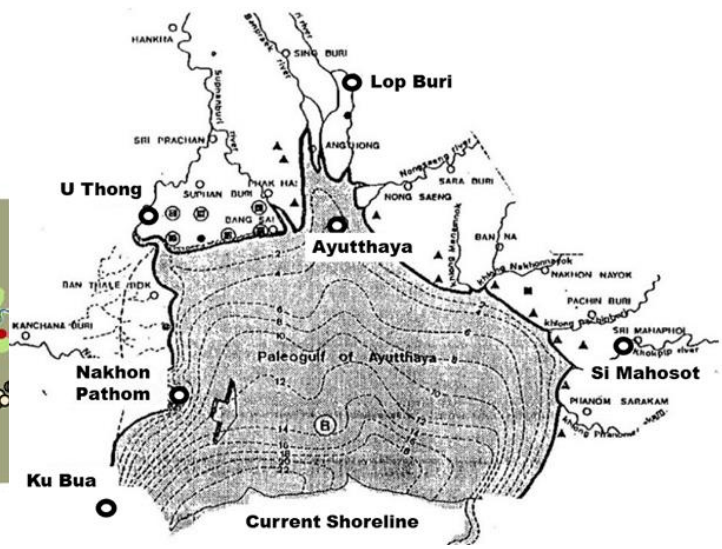


Figure 5: The Paleo-gulf of Ayutthaya
Source:[Jarupongsakul 1990]

Next, mapping the archaeological sites in the Ayutthaya period which is around 10 centuries later from the Dvaravati period is shown in Figure 4. As can be seen with comparing both Figures 3 and 4, many sites were appeared in Pathum Thani and Bankok areas. To analyze difference leading up to the Ayutthaya period (14-18 centuries) compared with the preceding period, it is necessary to consider the topographic geological processes behind the formation of the Chao Phraya delta. Let us see the previous study on geo-morphology of Ayutthaya in the Chao Phraya delta. It reveals that the previously described arc stretching from Khu Bua and Nakhon Pathom through Si Mahosot was once shoreline up to 5000 BCE. The body of water inside this shoreline was known as the 'Paleo-gulf of Ayutthaya' (Jarupongsakul, 1990). The existence of the former Gulf has been verified on the basis of geological investigations by drilling along its arc at 210 separate locations. An estimation of the shoreline is shown in Figure 5. Let us consider when the coastline of the present Gulf of Thailand was formed.

The paper "Evolution of Landforms and the Sites of Ancient Cities and Communities in Lower Chao Phraya River" (Pramojanee, 1995) states that the fossil record reveals signs that sea levels reached 20–50 meters above current levels in the prehistoric

period, and 10–20 meters above current levels from Dvaravati to Ayutthaya periods. Moreover, it has been estimated that sedimentation of the delta occurred at an annual rate of 26–36 millimeters in the process of its formation. According to this model, the shoreline would have reached its present-day location in the year 450CE. If the Dvaravati period began in the 6th century, these findings are in line with the historical facts of port cities being located U Thong and Khu Bua. Moreover, at the time of the transfer of the Ayutthaya capital in 1351, it is said to have been located on "a circular island, smooth level and apparently clean, standing in the middle of a large river" (Wyatt, 1984).

Since the transfer of the Ayutthaya capital, in 1687 a French survey of the flood plains of the Chao Phraya River basin found that Bangkok and Pathum Thani were formed by immense natural levees (Pramojanee, 1997). In other words, the Paleo-gulf of Ayutthaya, which described an arc, was a delta formed since 5000 BCE and is known as the new delta. According to the area-event mapping model previously described, let us summarize the relationship among time and space with the elevation which can be explained on the underground, surface, and aboveground. The time and space correspond the period between the Dvaravati and the Ayutthaya including the transition of annual change and the 'Paleo-gulf of Ayutthaya' respectively. A change which appeared in space 'Paleo-gulf of Ayutthaya' varies on the transition of time with sedimentation of the delta in terms of how high the sea level and where the shoreline of gulf was with the elevation. The reader can be understood that the study on geo-morphology affects the formation of land with the historical aspect including the human being. It may also be possible to understand the topological and geographical features on the view point of geo-informatics and are informatics by through simultaneous subterranean, surface, and aboveground overviews in terms of both time and space measures (Shibayama, 2012). That is one of cases as the area-event mapping model.

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