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# AN EXPLORATION OF BIG DATA AS THE BASIS FOR DEVELOPING A FLUID AND ADAPTABLE ARCHITECTURE PROGRAMMING

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*ABSTRACT*

*Many discussions have been devoted to the use of big data in architecture, particularly as a tool for data predictive analysis. Interpretation of big data rules, however, is rarely discussed. This paper explores the use of big data as a basis for programming architectures. It emphasizes the use of big data in design beyond predicting the future. Instead, it is a descriptive resource that transcends rigid data dependencies. This allows architectural program development to become more flexible and adaptable. This study was conducted using exploratory qualitative methodology. A variety of sources in Google were used to collect the data. By using the tracing method, a rule inquiry is conducted. To gain a better understanding of how big data can be applied in architectural programming, a rules-based design exploration was conducted. Based on the results of this study, the following methods may be used to determine the rules: (1) data collection for reading patterns, (2) trace lines as a basis for discovering rules, and (3) exploration of rules as a basis for programming design. The concept of architecture can be considered as a component that incorporates digital technology, which enhances efficiency and adaptability*

## 1. INTRODUCTION

The purpose of this paper is to examine the use of big data as the basis for a programming architecture. As part of the design process, a big data approach is being utilized. By viewing big data as a landscape that can be analyzed to reveal certain patterns, this paper examines the hidden knowledge in big data. A big data approach in the design process is used to guide the design process, especially during the early stages of the overall design process.

The use of big data in architecture has been widely discussed, particularly using data as a landscape that can aid the design process (Kitchin, 2014), both by describing current conditions and predicting future requirements (Jeble et al., 2016). As a landscape of architecture, big data has been extensively discussed in discussions of architectural design methods. This refers to the article The Big Data Analysis Challenge for Landscape Architecture by Don Royds (2018). It also refers to the book The Future Landscape of Architecture: data, methods, and programming by Yatmo et al (2020). In its context, it refers to a data landscape that can be used to design architectural projects, referred to in the article as a resource.

In the 21st century, big data represents one of the most important products, as data changes occur simultaneously with technological advances (Mikalef et al., 2019). As data becomes a commodity, it is used to produce goods arising from data interaction (Aaltonen et al, 2021). With the development of technology, it has become possible for us to interact with the virtual world in our daily lives. Every activity that we engage in every day can be recorded and read as a data landscape. As revealed Alkadri et al., (2015) variety of ways can be identified to identify place-making in everyday life that combines the virtual and the real spaces. It is imperative to note that place-making operates based on geographical space and interconnectivity. Developing a spatial network in social media, provides the possibility of integrating public engagement and place-making processes (Alkadri et al., 2015; Johanes, 2021).

In response to the changes in people's lifestyles that cannot be separated from technology and digitalization, the concept of connecting activities and technology has grown in popularity, including in architecture (Burry, 2020). The use of digitalization

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systems is essential for the creation of a smart city environment (Virkkala et al., 2017). One such method is useful for understanding cities based on landscape data (Kitchin, 2014). Big data technologies have become essential to the functioning of cities (Bellini et al., 2018; Ouafiq et al., 2022). In particular, how this data is seen as potential information generated by communication technology and the Internet of Things (IoT) (Fugini et al., 2021; Talebkhah et al., 2021).

Initially, architectural data consisted of information collected within the building, including post-occupancy evaluations, utilities, building services, transportation and infrastructure systems, and building management systems. Data collection, storage, and analysis have become easier due to the use of technology (Kitchin, 2014). Furthermore, data can also be used in wireless technologies, digital infrastructure, adaptive energy systems, network equipment, data collection devices, information and communication networks, automated systems, intelligent building management systems, energy efficiency measures, and wireless technologies. This article illustrates the sorting of large data sets to identify patterns through data mining. In contrast, data mining, which has existed to date, is a form of analysis that is either descriptive or predictive (Burry, 2020; Jeble et al., 2016; Mikalef et al., 2019; Rachmadika et al., 2022). By describing the data, we can gain a deeper understanding of it. The analysis provides insight into the characteristics of the data by revealing a pattern or insight. Predictive functions provide information about the future. Predictive functions utilize data analysis to extract patterns, correlations, and statistical regularities to generate insights into the potential outcomes of future situations.

This paper demonstrates that the data mining consists of two stages: (1) data collection and (2) data analysis. A data collection can be divided into several stages, including cleaning, integration, selection, and pattern evolution. Through cleaning, integrating, and selecting data, it is possible to ensure that the data is accurate, complete, repeatable, and relevant (Jeble et al., 2016; Mikalef et al., 2019). Patterns found during the pattern evolution stage are further processed during the data analysis stage. The next step in the process is the analysis of the data. The data set is analyzed so that it can be used to gain an understanding of the situation (Dumbill, 2013; Jeble et al., 2016). Data analysis involves using various techniques, including association, classification, decision trees, and clustering.

Though there have been many discussions about big data in architecture, little attention has been paid to the discovery of rules to guide architectural design. This paper examines the use of big data as a foundation for fluid and adaptable programming architectures. Rather than predicting the future, it focuses on the use of big data as a descriptive resource that is flexible and adaptable and goes beyond rigid data requirements. This paper uses case studies to obtain optimal results in utilizing big data, which pertains to train stations, particularly Tebet Station. A particular focus of this paper is on how big data can be used as a method to trace architecture as well as how these rules can be used to design the architecture.

## 2. BIG DATA IN ARCHITECTURE DISCOURSES

The purpose of this paper is to investigate the use of big data in architecture design, and in particular, the search for rules that can serve as a foundation for programming. In architecture, big data can be viewed as a component of technology and the digitization of data (Ma et al., 2021). It focuses primarily on data that has been recorded by technological means and can be accessed. This study aims to expand the discourse on big data in architecture, traditionally viewed as a description and prediction (Jeble et al., 2016). By exploring the data, we attempt to identify rules from existing data to develop architectural programs.

Big data generally refers to large data sets, but it may also have other characteristics. There are three characteristics of big data: volume, velocity, and variety. To better understand the three V's, Volume, Velocity, and Variety, please refer to Patgiri & Ahmed (2016). A volume is a measure of how much data there is. The amount of data contained in big data cannot be measured using a specific unit of measurement. Generally, large data are those that cannot be processed using conventional methods. The velocity of data refers to the speed at which it is generated and processed (Gonçalves et al., 2017).

As digitalization has become an integral part of daily life, large amounts of data have been accumulated that can be applied to several useful applications (Al Nuaimi et al., 2015). With the increasing use of digital devices such as smartphones and sensors, an unprecedented amount of data is being generated. This necessitates real-time data processing. Applications can be used to link data collected from smartphones directly to advertising or personal offers (Gandomi & Haider, 2015). Variety refers to the heterogeneity of the data set in terms of its structure. There are three types of data structures: structured, semi-structured, and unstructured. Text, images, sounds, and videos are examples of unstructured data. Semi and structured data are distinguished (Gandomi & Haider, 2015).

In the design of buildings, the use of data is not a new phenomenon (Oechslin, 1986). Design can be limited by client requests, structural calculations, and building regulations. There are some activities, such as structural measurements, MEP design, and some parts of the space program, which are traditionally data-driven (Loyola, 2018). In contrast, the aesthetic component of a building relies on intuition, experience, individual talent, and the implicit knowledge of the designer (Binnekamp, 2010). In all data-driven design approaches, the underlying assumption is that by utilizing more objective, measurable, and verifiable information in the design process, a better fit to client requirements and requirements is achieved by increasing awareness of constraints and opportunities, reducing bias when selecting options, and reducing risks when adopting solutions. As a general rule, it is important to minimize decisions that are made without a solid basis (Loyola, 2018). A project designed using a data-driven approach is not new in general. The use of data at an early stage of design, however, will lead to a new definition of data-driven design. This project is guided by data as an approach.

In addition, Redyantanu et al., (2022) suggest that virtual platforms are related to urban contexts, demonstrating how digitally recorded data can be viewed as a hidden system. Big data analysis involves studying large amounts of data to uncover hidden patterns and correlations (Yaseen & Obaid, 2020).To develop a more sustainable infrastructure system, digital technology must be integrated with the field context. Analyzing big data in architecture can also provide insights into how users represent a place by interacting with urban spaces and storing their behavior digitally. Johanes (2021) examined articles published in Indonesian architectural journals over the last decade to understand the current situation and present the country's challenges in developing architectural design discourse through digital data. Therefore, digital data can be viewed as a data landscape processed to determine keywords. Data is therefore of great importance at this time, especially with the advancement of digital technology. Technology has made it easier than ever to gather data previously obtained manually through measurements, calculations, and direct observation. For example, cameras that replace humans can be used to monitor human movements, visitor numbers, and visitor times. This can then be processed further to create an environment that accommodates or even improves the visitor experience based on the information collected. The architecture data can be used to develop design programming (Rachmadika et al., 2023)

A design approach based on big data may thus be developed as a basis for architectural programming. By leveraging existing landscape data, architectures can be presented more richly in the landscape. Data landscape refers to the understanding of every digital data that exists today as a diverse data landscape that can provide information about a particular condition. To understand the data landscape, one must understand all the digital data that exists today as a diverse data landscape that can provide us with information about a particular condition (Royds, 2018). An adaptable architecture must refer to digital data as a data landscape that can be traced to adapt as required (Yatmo et al., 2020).

## 3. METHOD

In this study, qualitative data was obtained through images from the Internet to conduct qualitative research. Creswell (2009) describes qualitative research as an exploratory study emphasising field data interpretation as the most significant factor (Creswell, 2009). This study uses digital media and technology to collect data. The goal of this research is to track data using big data through the use of technology and digital methods. Data was collected using Google Image Search and Pinterest.

The Google Search engine displays the most relevant information based on an index derived from its correlation with a database. Relevance of data can be affected by several factors, including location, language, and the device used to search (Google Developer). On the other hand, Pinterest, a social media site based on images, operates differently. In the search results provided by Pinterest, search results are based on the "value" provided by Pinterest based on the number of images or pins on that website, the popularity of the pins, the activity of the user who posted the pin, and relevance to the keyword or topic (Hafeez, 2022). Therefore, Pinterest search results will differ slightly from those of Google since they are influenced more by the user than by engineers.

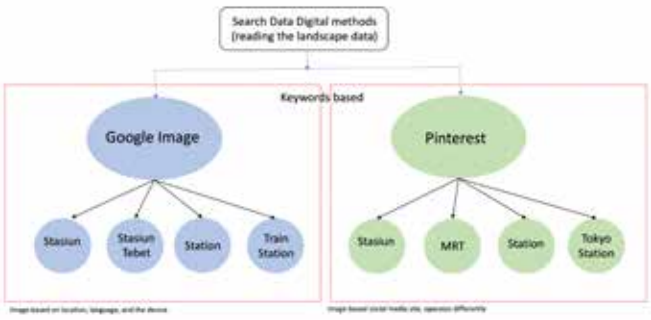



***Figure 1:*** *Data collecting*

Data sets were catalogued to conduct exploratory analysis. In cataloguing, data is grouped according to similar information. By using this method, it is possible to identify keywords that can be used as rules in architectural design (Yatmo et al., 2020). Based on the cataloguing results, architectural programming is compiled using the rules obtained. For a design to be appropriate, all possible options must be explored.

## 4. RESULTS AND DISCUSSION

In the context of big data search and exploratory analysis, the objective is to identify rules that can serve as the basis for architectural programming. The analysis of big data is an integral part of determining the capacity of a building, interpreting the meaning of cities, and understanding the daily lives of people who live in an environment. Based on the results of data analysis on similar buildings, an architect can estimate the capacity of a building or even redesign a building to match the predicted capacity in the future. The same principle can also be applied to a larger context, such as designing an environment or a city. The use of reading the data landscape as a basis for finding rules that will present a unique programming architecture has not been extensively studied. During the design process, rules serve as a boundary so that the design remains faithful to the original idea or basis. In addition to serving as the basis for constructing architectural programming, these rules also serve as the starting point. Through studies relating to the use of big data in architectural design, a method for preparing architectural programming can be developed.

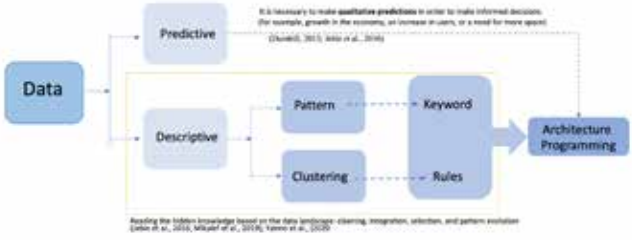



***Figure 2:*** *Data analysis process for architecture programming . Kasih gambaran tambahan di bagian architecture programming*

The search for rules has been carried out as a basis for developing architectural designs, by reading rules from object nature, which in turn form the basis for design development (Harani, 2023; Vidler, 1977), by reading rules from natural phenomena (Ball, 2009), or by reading rules as a basis for development. A design approach is presented using computational methods to design (Ummah et al., 2022). This study attempts to read patterns in big data to determine rules that can be explored to obtain a more fluid and adaptive design. As a basis for reading landscape data, data were collected, tracing was determined as a method of tracing rules, and exploration was conducted based on the rules obtained as a basis for developing architectural programming.

### 4.1 Collecting data for reading a pattern

The data collection and search are conducted using search keywords from Google Images and Pinterest. As a result of the differences between these two search engines, each search engine uses slightly different keywords. Four different keywords were used in the search, resulting in four different results. We used the following search words for Google searches: «station» for locating stations in general, «Tebet station» for locating stations specifically, «MRT station» for locating stations in Indonesia, particularly Jakarta, and «train station» for locating stations in other countries.

For Pinterest searches, the following keywords are used: “station” to locate stations in general, “MRT Jakarta” to locate other stations facilities in Jakarta, “train station” to locate train stations abroad, and “Tokyo metro station Japan” with one of the best commuter rail transportation systems. Tebet station’s search results were not taken into account because insufficient data was available, particularly relevant to the search term. Even though the same keywords are entered in both search engines, the results they produce will differ. Based on a search on Google, the top 387 images have been selected. The following is a list of Pinterest›s top 441 images. In addition, search results are displayed differently, resulting in very different numbers. A count of all images captured follows five full-screen recordings.

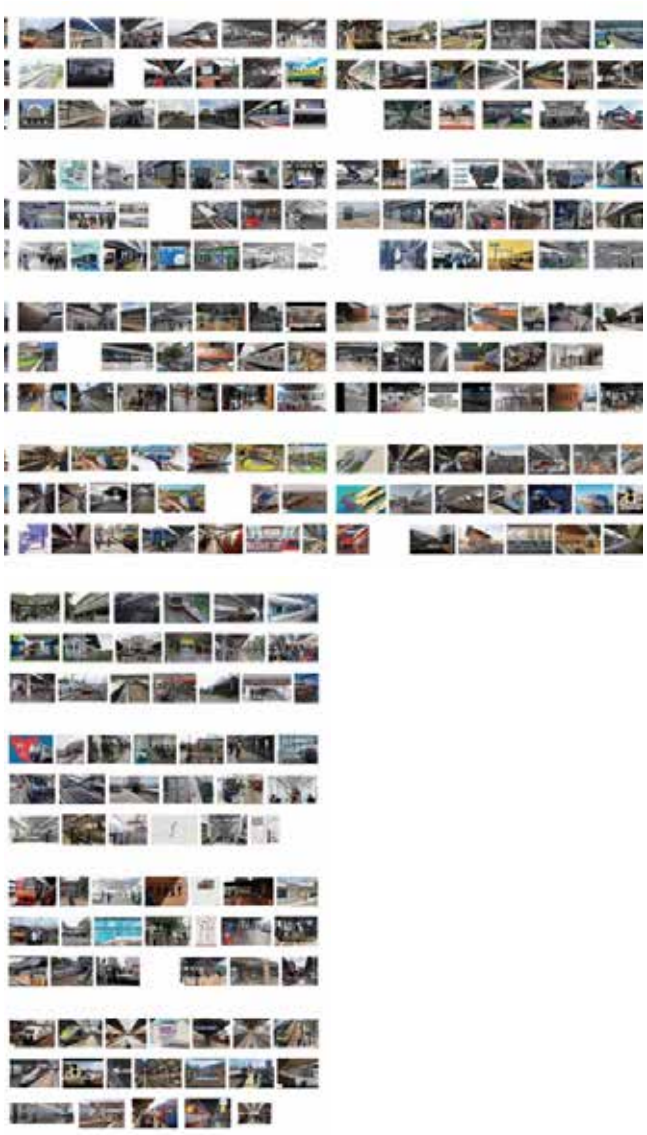
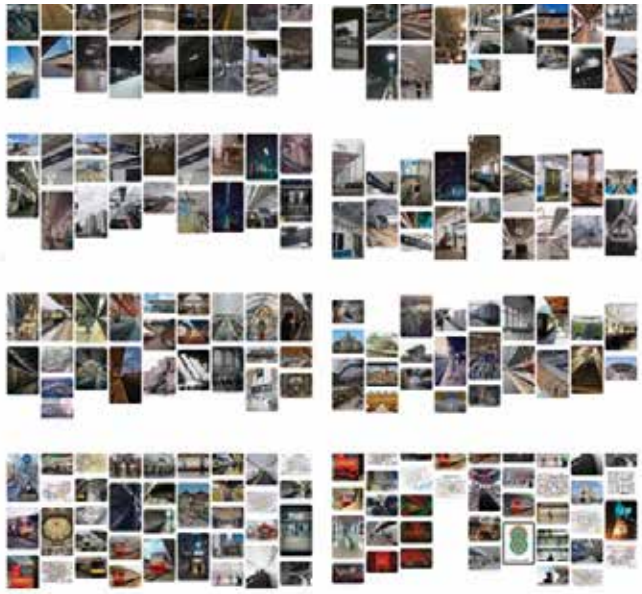


***Figure 3:*** *Datstation from Google Image*



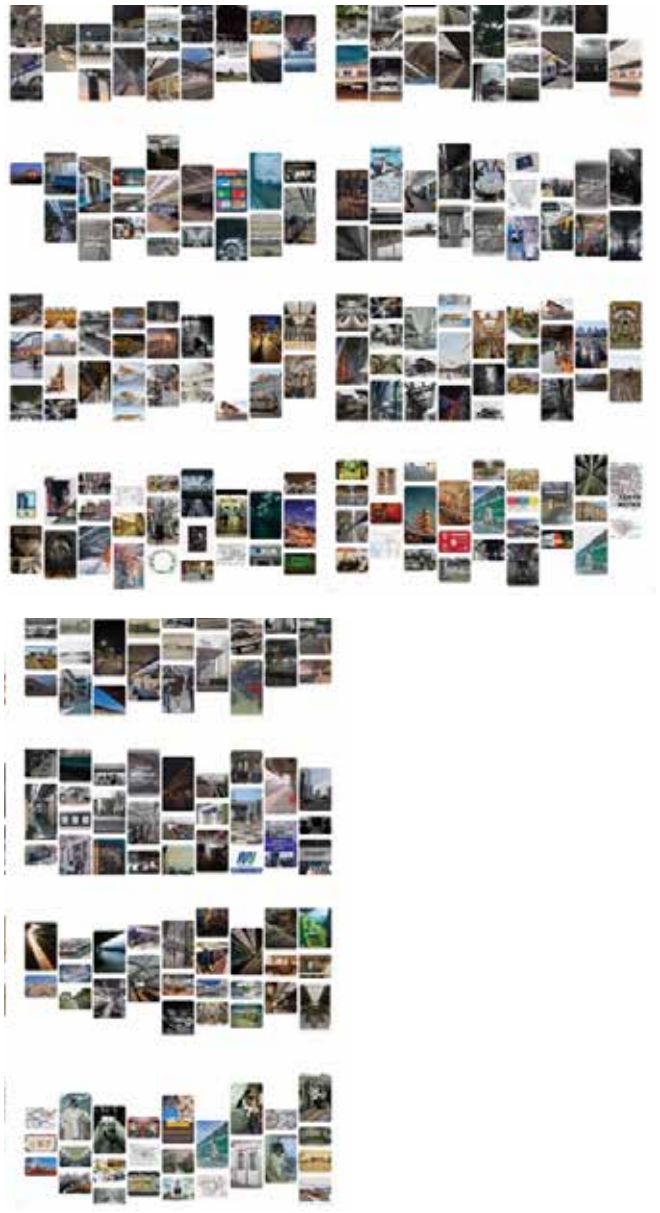


***Figure 4****: Data image of the station from Pinterest*

Data search results are compiled and catalogued based on the search source used to search. The data obtained through these two sources of information are catalogued to facilitate the understanding of the pattern and the retrieval of the data. Using digital records and technology, this tool can display the meaning of keywords appearing in the document. As a result, the catalogue is used to read the rules in the data based on what is known about the catalogue.

### 4.2 Tracing line as a basis for finding the rules

The tracing method is used to find rules out of hundreds of data sets by focusing on the arrangement of lines that make up the fields in the photo. A persistent approach to reading patterns becomes crucial at this stage. Among them is selecting a method or pattern that is repeated and constructing an image based on the results of the previous data analysis. In Figures 5 and 6, the line serves as a means of composing data in the form of photographs. To trace the rules, the data is not only observed directly but also interpreted through the meaning of the photograph. It is necessary to trace the lines in the data to perform the tracing method. Lines are shaped by the shape of objects, subjects, and forms. These lines represent patterns seen in people's perspectives.

***Figure 5:*** *Data from Google Image traced*

***Figure 6:*** *Data from Pinterest traced*

The original image and line tracing results should be separated from the traced image to avoid complicated and confusing readings. Creating rules from line shapes in this manner makes it easier to read them. Following this, the tracing results for each image are analyzed and the pattern's shape is analyzed. Following the processing of these data in the form of lines, they are grouped into two clusters, "centred patterns" and "diagonal lines". A centred pattern refers to a pattern that is centred around a point. Asymmetrical or symmetrical arrangements are possible.

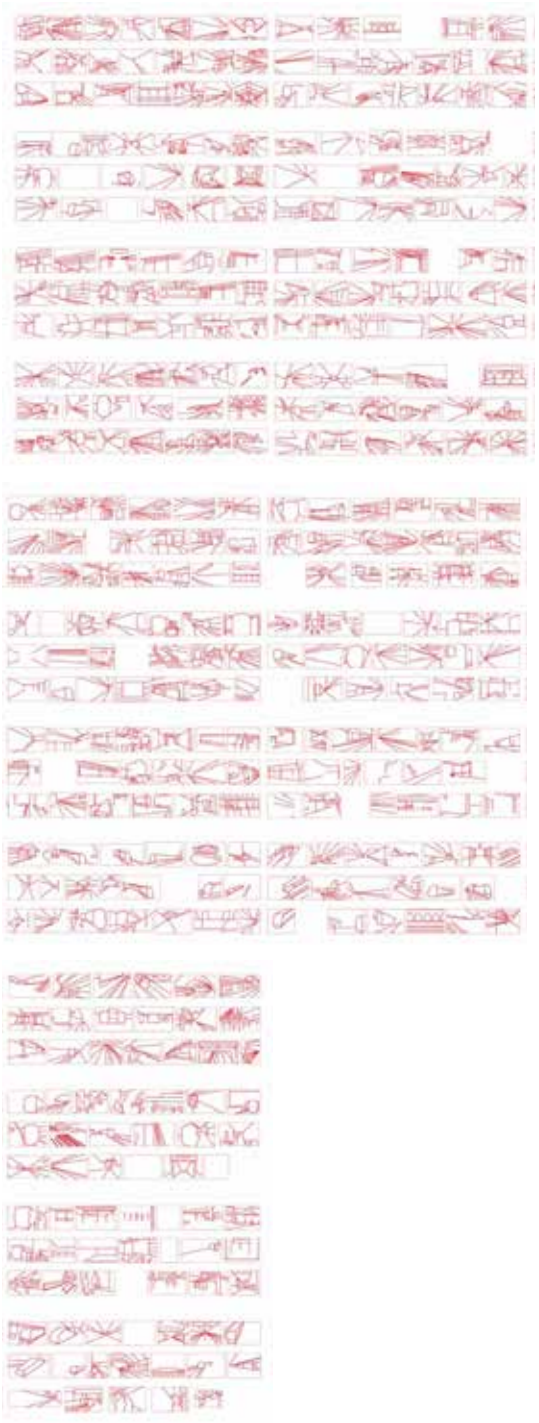


***Figure 7:*** *Lines formed from Google Image data*

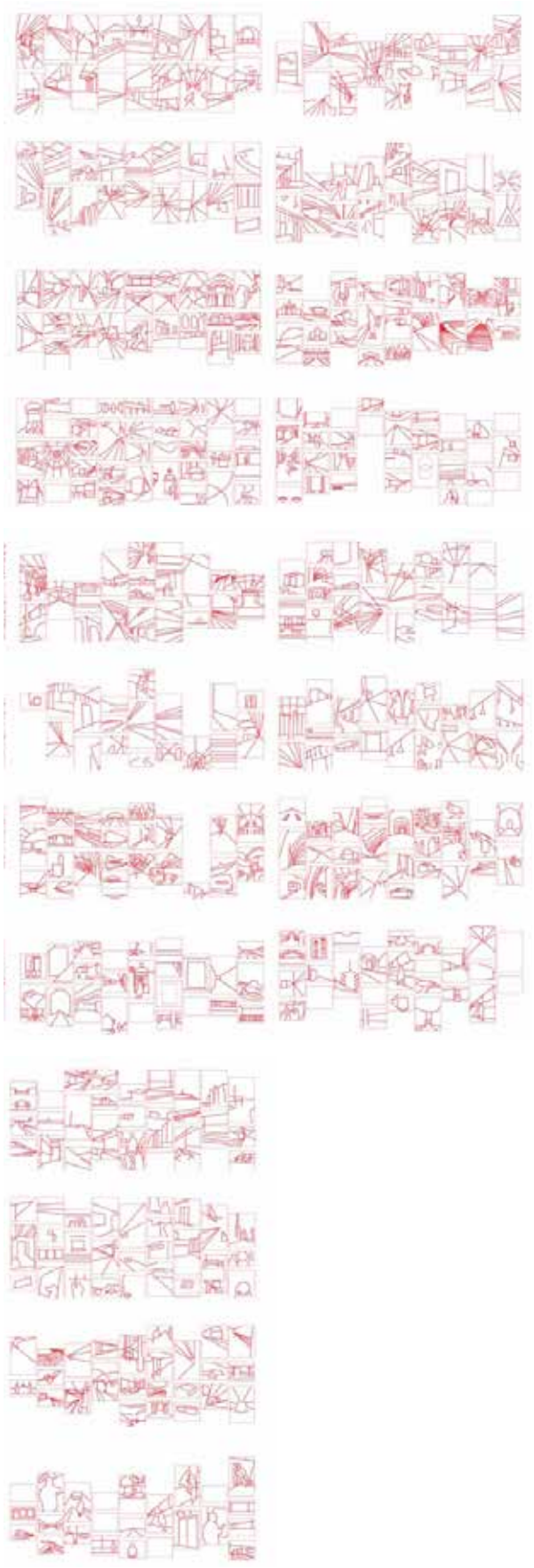


***Figure 8:*** *Lines formed from Pinterest data*

An image with diagonal lines is characterized by lines that are not parallel to the image's edges. Two types of lines can be used: straight lines and curved lines. Figures 7 and 8 demonstrate how the tracing line method works by redrawing lines over objects and subjects within the image. Due to the differences in the conditions of each photograph, patience and accuracy are required during this process. Sometimes the lighting and distance between objects and subjects were so unclear that it was difficult to draw lines between them. The following discussion will describe how tracing can be used to interpret exploration results.

### 4.3 Exploring Rules as a Basis for Programming Design

A set of rules derived from big data will be used to develop architectural designs for public facilities, particularly train stations. In this section, we will provide an example of how the results of big data exploration can be used to design train stations. In applying rules to design development, we can identify probabilities for which parts of the rules may be implemented.

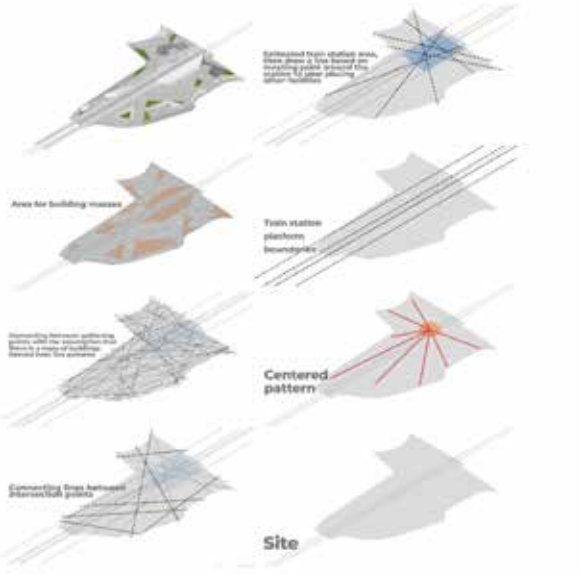



***Figure 9:*** *Site plan making using keywords found using big data*

The process of developing rules begins with determining the probability of implementing certain parts of the design rules. To examine the design to which rules can be applied, apply a "pattern-centered" rule to the entire site setup. To create a centred pattern, you should first draw simple lines within the site. Mark out the station platform area and the area of the train station itself by drawing the necessary boundaries. In the next step, add the rule "diagonal plane" to the line, resulting in an intersection with the existing line. As a result, additional diagonal lines should be added to the existing intersections at this point, since you cannot determine the shape of the building mass. The process of adding lines continues until all intersecting lines have been connected. The exploration continues by making shapes following the space's requirements. To make them compatible, especially to make the entire building mass cohesive, the last part requires some formability.

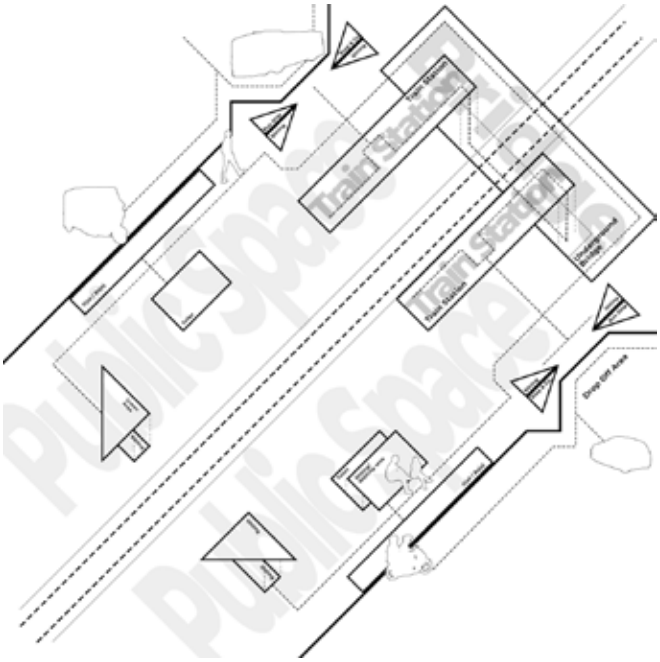



***Figure 10:*** *Building programming*

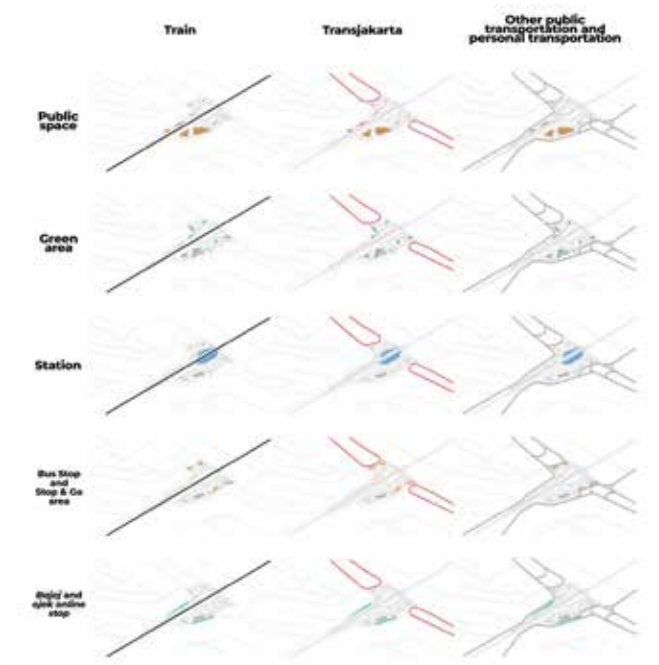



***Figure 11:*** *Relation between facilities and transportation lines*

By categorizing and tracing the data, and then using the line-tracing method to search for rules, the findings of the rules were explored in a programming design, demonstrating that big data can be used to create an architecture that focuses on exploration. The use of big data can provide flexible and adaptable rules based on the landscape data obtained and the capabilities of the exploration process, which have been used for many years as a basis for programming. The three processes above demonstrate that architecture is integral to digital information and technology. According to Jeble et al., (2016), this adds to the use of big data in architectures that are perceived as predictive, such as the financial sector. This article examines the possibility of developing a big data-based design based on the rules derived from pattern data.

## 5. CONCLUSION

As this article demonstrates, big data, especially image searches using specific keywords, can be used to detect patterns within data sets. This data can be used to develop architectural design rules based on landscape data. This article also illustrates how line tracing can be used to focus results from data found, particularly for rules that can only be explored exploratorially. Particularly in the context of architectural discourse, it opens up a wide range of opportunities for big data exploration methods. Using big data can present fluid and adaptable rules based on the landscape data obtained and its exploration capability, while searching for rules as a basis for programming is not new.

This article aims to demonstrate that patterns can be identified by reading big data, particularly image search data. These patterns provide the basis for the development of architectural design according to rules. This article suggests that “centered patterns” and “diagonal planes” patterns can be applied to the development of site plan layouts and building mass designs. Moreover, this article illustrates how the development of rules for preparing architectural designs can provide a range of opportunities that can lead to the development of the most effective designs. Therefore, rules can be used to communicate the overall concept and message of a design to clients and stakeholders. According to the article, the keywords “centered pattern” and “diagonal plane” can be used to convey the building’s overall design concept and mass.

The findings of this study expand Alkadri et al.’s (2015) statement that revealed the use of big data in developing architectural programming, in addition to representing everyday life in urban settings. As well as illustrating the possibility of using big data as a basis for keyword-based architecture programming, it adds to the ideas presented by Rachmadika et al. (2023).

According to the article, big data can be an effective tool for developing architectural designs. To develop architectural designs, big data can be used to identify patterns that can be used as keywords. The search method can be used to focus the results of the data. By developing rules as a basis for preparing architectural designs, a variety of opportunities can be created that can result in the most effective designs being produced.

The use of big data in the search for rules may result in fluid rules that can be adapted based on the landscape data obtained and the exploration capabilities of the system. As demonstrated in Reading a Pattern, Tracing Lines as a Basis for Finding the Rules, and Exploring Rules as a Basis for Programming Design, architecture is a component of the design process that incorporates information and digital technology to facilitate fluidity and adaptability.

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