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실내 공간에서의 문자매칭 기반 지오코딩 기법

A Geocoding Method on Character Matching in Indoor Spaces

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요 약 최근 위치 정보의 이용이 여러 분야에 걸쳐 급격하게 증가하고 있다. 실외에서는 위치 정보의 획득을 위해 일반적으로 GPS 기술을 사용하였으나, 복잡한 실내 공간에서는 벽, 기둥과 같은 물리적인 장애물들로 인해 발생한 다중경로 간섭으로 무선 근거리통신망, RFID, 블루투스 등의 무선 네트워크 기술을 적용한 연구가 진행되었다. 그러나 이러한 위치 측정 기술들은 센싱 인프라스트럭쳐 구축비용이 많이 들며, 측위에 있어 계산 집약적이고, 실내 구조에 따른 정확도의 변화가 발생하는 한계가 존재한다. 본 연구에서는 이러한 한계점을 보완하고자 복합용도건물 내에서 쉽게 획득 및 식별이 가능한 상가, 컨벤션 센터 및 오피스의 전화번호, 방 번호, 상호명과 같은 서술 데이터를 이용하여 위치를 추출한다. 이 과정에서 문자 매칭을 활용하며, 위치 추정에 있어 신속한 계산과 실내 환경에 따른 정확도 변화를 배제하기 위해 지오코딩 방법을 적용한다. 본 연구에서 제안된 방법을 아키텍쳐로 설계하며, 구현을 위해 3차원 가시화 프로그램을 개발한다. 또한 제한된 기법에서의 매칭률, 프로세싱 시간을 통하여 정략적으로 평가한다.

키워드 : 위치 정보, 실내 공간, 서술 데이터, 지오코딩, 문자 매칭.

Abstract Recently, the use of locational information is growing rapidly. GPS technology has been adopted generally for obtaining locational information in outdoor spaces. In the other hand, the researches on indoor positioning have been carried out applying WLAN, RFID or Bluetooth technology because of the multi-path interference of GPS signal caused by the physical obstacles such as walls or columns in buildings. However, such technologies for indoor positioning cost too much to build sensing infrastructure and compute-intensive processes are involved. Furthermore, the accuracy of location estimation is variable caused by interior structures in buildings. In this study, to make up for the limitations, descriptive data such as phone number, unique room numbers, or business names readily available in mixed-use buildings is used for extracting location information. Furthermore, during the process, a geocoding method using character matching is applied to this study enabling prompt location estimation and sublating the fluctuation of accuracy caused by interior structures. Based on the proposed method in this study, an architecture is designed, and three-dimensional viewer program is developed for the implementation of this study. Also, this research is quantitatively analyzed through match rate and processing time of proposed method.

Keywords : Location Information, Indoor Spaces, Descriptive Data, Geocoding, Character Matching.

1. Introduction

Recently, the smart phones are supplied widely, and development of location based services is increasing rapidly. Location information in the services is basically used with attribute data as non-spatial information. So such location based services enable users to obtain related information about shopping, travel and transportation for human activities. Due to the fact that GPS module

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is equipped in the smart phones, location information can be obtained at real-time from the GPS satellites and thus, the use of rate of location based services has increased. GPS as one of positioning techniques is widely used for finding location information in outdoor spaces.

The range of human activities has expanded from outdoor spaces to complex indoor spaces due to the emergence of large-scale mixed-use buildings[13, 14]. And not only horizontal activities in each floor, but also vertical activities between floors in a building have been accompanied. Location based services in such indoor spaces compared to those in outdoor spaces using GPS, have required alternative positioning techniques because of the multi-path interference of GPS signal caused by the physical obstacles such as walls or columns in buildings. Thus, the researches on indoor positioning have been carried out using WLAN[9, 15], RFID[3] and Bluetooth[6]. However, these technologies based on radio frequency commonly cost too much to build sensing infras[4] 爀攀cture, and compute- intensive processes are involved. Also, accuracy of positioning using the technologies is variable in indoor spaces. Therefore, the research on alternative methods for location estimation in indoor spaces is necessary. Those methods should require at least that positioning process is simple and representing a location with satisfactory accuracy is at low cost in order to overcome the existing limit.

Thus, in this paper, we propose a geocoding method in indoor spaces for estimation of a location. Descriptive data is used in order to avoid complex calculation process for representing the location, and it includes shop name, restaurant name, room number and telephone number. The descriptive data is readily available and represents spaces simply. In order to convert the descriptive data into text data which is a form possible to be analyzed and processed, OCR(Optical Character Recognition) is applied. The OCR technology recognizes and extracts the text data from the descriptive data, and it has grown with template matching and structure analysis in the pattern recognition field[16].

Based on the geocoding method considering the application of descriptive data in indoor spaces, indoor space geocoding architecture is designed. And then 3D viewer program is developed. In particular, the viewer program displays several floors with many sample rooms in indoor spaces and marks the location which the descriptive data indicates. In addition, a query service based on the architecture is implemented using related search terms.

2. Related works

2.1 Geocoding Method

The geocoding is generally a process of deriving geographic coordinates from geographic data such as addresses or postal codes through matching the data with reference database. Parsing, matching and locating are fundamental processes in the general geocoding[12]. Firstly, parsing process converts address data into standardized format. Secondly, matching process matches the input data with pre-built reference database, and selects result records. Lastly, locating process extracts geographic coordinates of locations from the result records. During the processes, various geocoding methods are applied, and in terms of the methods, the address matching technique[5] and the 2D and 3D area-based address matching technique[12] have been researched.

2.1.1 Address-matching Method

The address-matching method is developed for the purpose of avoiding enumerators being dispatched to each dwelling unit for allocating population by the U.S. Bureau of the Census, and it is based on street name address[4]. In order to find exact geographic coordinates extracted from the matching and location processes, the reference database should be designed including both address information and location information. Each record from the reference database expresses the information on each road segment. Attributes of each records are low and high addresses, geographic coordinates of the addresses, directional prefix, street name and type, directional suffix. Matching process of the reference database and target database consists of batch matching and ih rractinfomatching. The batch matching automatically matches street name and type, and directional information of each record in target database with those information of the reference database. In the case of unmatched records, ih- rractinfomatching datually matches the unmatched recordsation amro have misspellings, abbreviations or any other errors with the reference database. And then, after the parity check that every record of target database is whether even or odd side of each road sement using street address, approximate coordinates are calculated through interpolation using low and high addresses, and coordinates of those.

2.1.2 Area-based Address Matching Method

2D and 3D area-based address matching method has developed for the address system based on administrative divisions like Japanese addressing system and, by extension, for 3D geocoding in tall buildings and apartments. Firstly, 2D area-based address matching method consists of two steps. For the first step, address is geocoded on a block. For the second step, the position of a building is consequently defined within the block based on the building number interpolating the location approximately to the center of the building. Secondly, 3D area-based address matching method geocodes a building address and a subunit address. The building address means typical address information based on street or area system. In addition to the building address, the subunit address means each room number in the building. The location of a building is geocoded using address point matching method[18] and then for the interior geocoding of the building, exact location in a room on a floor is geocoded by interpolation on the basis of 3D network model.

In this study, address-point-matching method is applied to find the location quickly without any interpolation process in indoor spaces structured with irregular spaces. Also, matching process between the text data extracted during character matching process and a reference database is modified for increasing automatic match rate in indoor environments.

2.2 Indoor Positioning Method

Researches have been carried out for indoor positioning using wireless network technology such as WLAN(wireless local area networks), RFID or Bluetooth. Firstly, indoor positioning based on WLAN has been initially researched using trilateration method[15]. In addition, the study using fingerprinting method has been carried out[9]. Furthermore, the complex research using Bayesian filtering by considering the change in signal strength over time has been carried out[10, 24]. Secondly, RFID basically requires two factors, transponder(tag) and reader, for indoor positioning[7]. Especially, LANDMARC uses radio frequency map built by pre-installed active tags[17]. The RFID positioning, however, requires at least three readers for location estimation and simultaneous detection of a tag by the three readers is difficult due to the limitation of RFID antenna. So RFID indoor positioning based on probabilistic RFID map and Kalman filtering methods has been proposed to solve these problems. Lastly, Bluetooth as IEEE standard 802.15.1, is mounted on most mobile phones. The research considering the application of trilateration method using RSSI has been carried out[6].

Overall comparison between three kinds of in-

Table 1. Comparison between indoor positioning methods

Positioning / Comparison	WLAN	RFID	Bluetooth
Accuracy	3~30m	1~2m	2~3m
Delay	0.01~5.00s	7.5s~	20s
System components	Wireless APs and Location server	Readers, Tags, Wireless network and Location server	Positioning server, Wireless APs and Tags
Other	Error occurrence caused by physical obstacles and moving people		

door positioning methods is summarized in Table 1 as below. In terms of accuracy, WLAN has sensitive error range caused by indoor environments and variety filtering methods[23]. Delay of RFID for location estimations is at least 7.5 seconds[17]. That is the average time unique ID signals are transmitted by tags. On the other hand, Bluetooth takes the longest time, 20 seconds, for indoor positioning[8]. And RFID system fundamentally requires the largest components between the comparable positioning methods. Above all, all of these methods commonly cause error from radio frequency interference by physical obstacles and moving people.

Thus, in this study, the indoor geocoding method using descriptive data is proposed to overcome the limitation of radio frequency and building infrastructure. The descriptive data is possible to be obtained easily in indoor spaces and the geocoding can simply find location without the complex estimation process.

3. Indoor Space Geocoding Method Using Character Matching

The research direction is to modify existing geocoding method in order to integrate with character matching. In addition to the existing geocoding method, recognition function is added to recognize descriptive data in indoor spaces as shown in Figure 1. The descriptive data is converted into text data through the recognition function, and the text data is parsed and matched for finding corresponding spatial object information from reference database. Parsing and matching functions are modified for increasing automatic matching rate taking into account misrecognition of characters. And next, consequently, (x, y, z) coordinates of the object are extracted through location function.

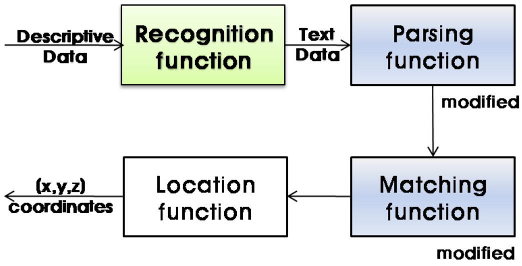


Figure 1. Flow diagram of indoor space geocoding method

3.1 Recognition of Descriptive Data and Extraction of Text Data

As a way to recognize descriptive data automatically, character recognition technique is utilized. Character recognition technique is typically divided into two groups depending on the method of data acquisition and processing: on-line and off-line recognition[19]. Both of them, the off-line recognition obtains text data from fixed static character on documents or mailing envelopes using a scanner or digital camera. On the other hand, the on-line recognition obtains text data from handwriting using an electronic pen. So, the off-line is suitable to this study for capturing visual information from image data such as business names of shop signs or room numbers of office rooms in indoor spaces. The off-line recognition is generally classified into four stages: 1) preprocessing, 2) segmentation, 3) feature extraction and recognition, and 4) postprocessing.

3.1.1 Preprocessing

Prior to recognition of the characters shown in a image, preprocessing is necessary to improve the recognition rate through image conversion. The image conversion is composed of normalization and thresholding. First, normalization is the process to obtain standardized data[2], and its methods are slant normalization and size normalization. Slant normalization is essential for an effective character segmentation and recognition to calibrate rotated characters using various techniques. And size normalization fix the size of characters to the standardized size, and one of methods uses linear interpolation using 16x16 grid[11]. Second, in order to reduce image data size and increase processing speed converting the images into binary images, thresholding is required. The thresholding calculates threshold value(s) to generate binary images. The threshold value is automatically calculated by various algorithms, and among them, the simplest type of algorithm is to use the mean or mode. A binary value of each pixel by a threshold value is assigned by the function below. If a image is defined by coordinates (x, y), gray level for each pixel can be expressed as $f(x, y)$. And assuming that t is the threshold value and $B=\{b_0, b_1\}$ is a pair of binary values, t is b_0 when t is less than the threshold, otherwise, t is b_1. As a result, the image can be divided into white background and black characters.

$$f_t(x,y) = \begin{cases} b_0 & \text{if } f(x,y) < t. \\ b_1 & \text{if } f(x,y) \geq t. \end{cases} \quad (1)$$

(Trier O.D and Jain A.K, 1995)

3.1.2 Segmentation

Segmentation is a process to split text strings into each row, words and characters. Among a variety of met of , the met of of projection profile et ofhistograms[2ofhiFor the distinction between each row, peaks and valleys of horizontalf histogram profile made of binary-valued pixels are et d to find cuts. In a specific row, segmentation of words and characters is performed by the vertical histogram profile.

3.1.3 Feature Extraction and Recognition

Feature extraction process analyzes character pattern's properties, and distinguishes letters based on various types of analysis methods. Not only binarized raster image, but also gray scale image can be used for the feature extraction, or thin lines, skeletons or contours can also be used[22]. Especially, the method of using contours involves a polygonal approximation to reduce the size of image data and to be expressed in a form that is easy to recognize.

For the recognition process, many segments of the polygonal approximation are used as features to match itself with prototypes[20]. For the matching process, following equations are used to find best matched prototype. The squared Euclidean distance d between a feature and a segment of the nearest prototype is calculated. And a weighted difference w of the angle Θ from the prototype. Then, the distance d_f is calculated from each feature adding d^2 to $\omega\Theta^2$.

$$d_f = d^2 + w\theta^2 \quad (2)$$

The evidence E_f is calculated using the distance d^2_f and the constant k and it is inversely related to the distance d_f.

$$E_f = \frac{1}{1 + kd_f^2} \quad (3)$$

The E_f is replicated to the E_p of the value of the prototypes. The number of features N_f and sum of prototype lengths L_p are used to normalize the sums of feature and prototype evidence due to the difference of the sums. Finally, d_{final} is calculated as a distance value.

$$d_{final} = 1 - \frac{\sum_f E_f + \sum_p E_p}{N_f + \sum_p L_p} \tag{4}$$

3.1.4 Postprocessing

The postprocessing improves the accuracy of character recognition taking the semantic information of language into account. In other words, the postprocessing analyzes the context of text strings, whereas previous works only analyze the shape of the strings. Some feedback from this process are provided to the previous works. One of various methods is matching with dictionary data to correct the spelling of recognized words. And the other, HMM(Hidden Markov Model) technique, uses the statistical information from trained data.

3.2 Parsing and Matching

The location information in indoor spaces is extracted matching the text data from recognition process with a reference database. First the reference database for the matching process should be designed in advance, and the details for accurate matching process should be defined.

3.2.1 Design of Reference Database

The reference database contains the semantic information about indoor shops, restaurants, convention halls or office rooms for matching the extracted text data from recognition process as well as the location information. The reference database is basically designed as shown in Figure 2.

The Feature table stores semantic and spatial information describing objects in indoor spaces. An identifier of each object is stored in ID, and a floor number on which a object locates and a room number are stored in each attribute. Also, x, y coordinates of the object can be stored in COORDS attribute. As a foreigner key, R_ID is designed for linking with Room table, and it refers to ROOM_ID of the Room table. The Room table stores phone numbers and the types of ob-

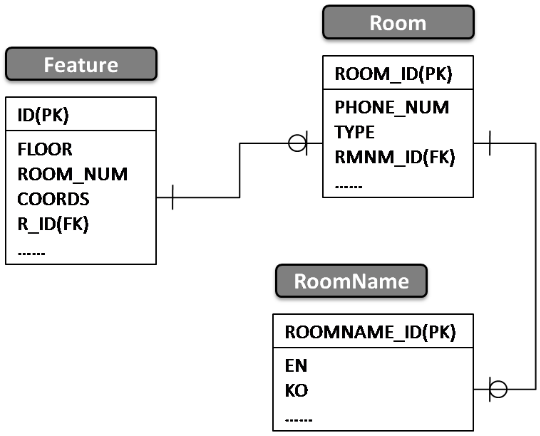


Figure 2. Reference database design

jects as the code list which could be shops, restaurants, conference rooms or office rooms. RMNM_ID as a foreigner key, is designed for linking with RoomName table, and it refers to ROOMNAME_ID attribute of the RoomName table. The RoomName table contains basically English and Korean name of each store, restaurant or convention hall. Apart from those languages, the names in any kind of languages can be stored.

3.2.2 Character Matching

For matching the text data extracted from descriptive data with the reference database, the text data is primarily subjected to be refined. The refinement converts the text data into the form which can be comparable to corresponding attribute in the reference database. For example, the text data goes through removing hyphens, commas, periods or edge spaces.

And next, the text data is classified into one of many categories such as a room number, business name and phone number. This classification process is necessary for the comparison operation between the text and corresponding attribute in the reference database, and for the additional refinement of the text data. The classification algorithm of text data is shown in Figure 3.

The text data t_{st} is extracted from descriptive data D through recognition process. Firstly, the

```
Input: DescriptiveData D;
       Minimum digit numbers of phone
   number mp;
tst←CALL OCR(D)

Procedure ClassificationProcess(tst){
        IF (tst consists of numbers & tst.length > mp)
                pn←tst
                rpn←CALL Refinement(pn)
        ELSE IF (CALL IsRoomNum(tst)=true)
                rn←tst
        ELSE
                bn←tst
        END IF-ELSE
}
```

Figure 3. Classification algorithm of text data

phone number *pn* is a combination of numbers, and digits are limited. Thus it can be separately distinguished from a room number and business name. Secondly, room number *rn* is distinguished from a business name *bn* through IsRoomNum based on a combination of numbers or rule combinations with a specific number of digits of the alphabet and numbers. The phone number *pn* is especially goes through a secondary refinement. The presence of the area code of the phone number in the text data is critical to decide whether it can be matched with corresponding attribute in a reference database. So the area code is deleted from the text data or added to it.

After the refinement and classification process, matching process follows, and it compares text data with a reference database through full, partial and manual matching sequentially. Firstly, full matching simply checks the identity through the comparison between text data and corresponding attribute in a reference database. If the text data is not matched with the attribute perfectly, secondly, partial matching follows. The partial matching is performed for business names composed of a combination of several words. The text data is split into several words based on the spacing between words, and the split words are compared with those of corresponding attribute. If the same attribute cannot be found even after the full and partial matching, users directly input data or select one from a candidate list through manual matching.

The whole matching process algorithm is performed for the business name as shown in Figure 4. First of all, the full matching for the input business name *bnt* is performed. If the matched value *output* is exactly one, its corresponding coordinates are extracted via the reference database. Otherwise, if the matched value does not exist since the business name is misrecognized, the text data goes through the partial matching. The partial matching finds matched attributes searching each record of business name attribute bnt_{att} in the reference database, and the result values

```
Input: Boolean b;
       Array output;
Procedure MatchingProcess(businessname bnt){
  output←CALL FullMatching(bnt)
  IF (output.length = 1 )
    CALL Location(output)
  ELSE IF (output.length = 0 )
    FOR each attribute bntatt from ReferenceDB
      b←CALL IsContained(bnt, bntatt)
      IF (b)
        output←bntatt
      END IF
    END FOR
    IF (output.length = 1)
      CALL Location(output)
    ELSE
      CALL ManualMatching(bnt)
    END IF-ELSE
  END IF-ELSE
}
```

Figure 4. Matching process algorithm

are stored in *output*. If the result value is only one, corresponding coordinates are extracted. Otherwise, the manual matching follows.

As a result, all of these parsing and matching processes are represented as a data flow diagram in Figure 5, and described below:

1) Text data is obtained from descriptive data through recognition process.
2) The text data is converted into a standardized form through refinement.
3) Classification process distinguishes the text data based on several types which describe objects occupying spaces.
4) Corresponding attributes of each record in the reference database are searched through based on the types.
5) Full matching finds identical attribute value from the reference database. If the matched value is exist, corresponding location information is extracted.
6) Otherwise, the text data is split through the partial matching, and matched attribute values containing one of the split words are searched.
7) If the number of matched attribute value is only one, the corresponding location information is extracted.
8) Otherwise, the manual matching is performed so users manually input text strings correcting misrecognized text. And finally the corresponding location information is extracted.

Location information is extracted as two-dimensional x, y coordinates. Based on the coordinates, the location can be displayed as a point, symbol or polygon on the geometrically defined three-dimensional building.

4. Implementation and Analysis

In this chapter, first of all, architecture is designed based on a geocoding method in indoor spaces using character matching, and a viewer

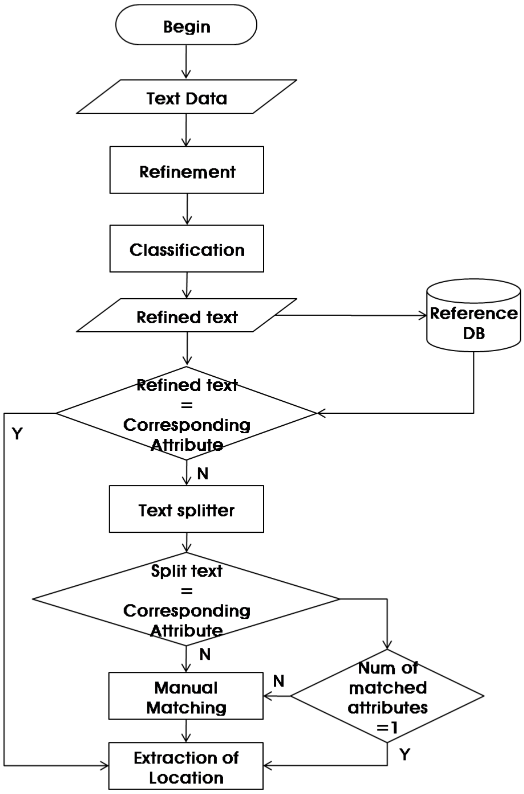


Figure 5. DFD of Parsing and Matching

program is developed on the basis of the architecture. Also, quantitative analysis is performed for the architecture.

4.1 Architecture Design

The overall architecture includes a input module, refinement module, network module and database retrieval module, and finally output and display location information as shown in Figure 6. As a first step, text data is extracted from descriptive data through the input module. Next, as a second step, the text data is standardized through the refinement module, and query statements are created based on the refined text data through the query generator. Finally, the queries are sent to a reference database, and location information is extracted through database retrieval module.

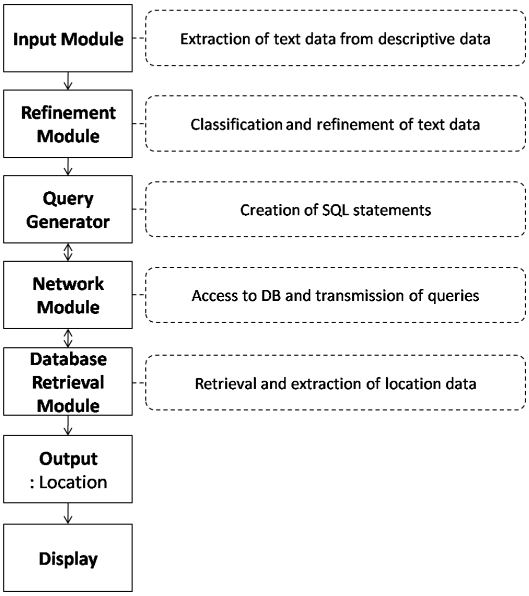


Figure 6. Indoor space geocoding architecture design

4.1.1 Descriptive Data Input

The input module is designed for extraction of text data from descriptive data such as business names, phone numbers or room numbers in mixed-use buildings, and represented in Figure 7. For obtaining the descriptive data, the camera component captures image data from camera-equipped mobile devices, and it compresses and stores the image data as an appropriate file format. And next, the image data is sent to the OCR engine. The OCR engine recognizes and extracts text data from the image through preprocessing, segmentation, feature extraction and recognition, and postprocessing.

4.1.2 Refinement of Text Data

The refinement module is designed for refinement and classification of text data as shown in Figure 8. Extracted text data is adjusted for the standardized structure through the refinement component, and then classified into a phone number, room number or business name through the classification component based on the classification algorithm. After that, queries are created by the query generator for searching corresponding attributes in a reference database.

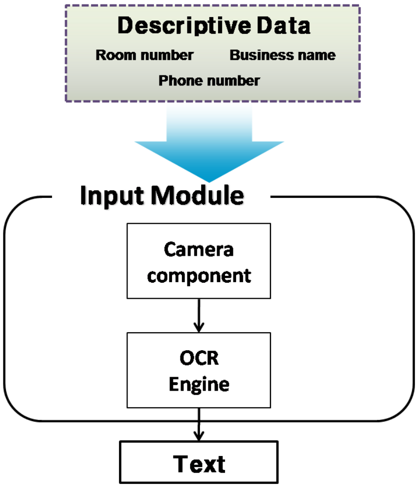


Figure 7. Input module of Indoor space geocoding architecture

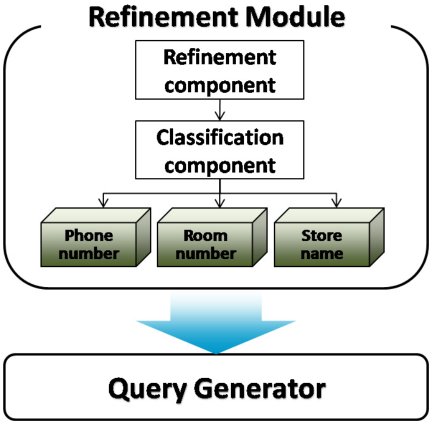


Figure 8. Refinement module of Indoor space geocoding architecture

4.1.3 Retrieval and Data Output

For searching attributes of tables in the reference database using queries, the network module and database retrieval module are required as shown in Figure 9.

The network module configures the communication protocol between the client and the server, and connects the client side to the reference database of the server side in order to transmit queries. In the database retrieval module, query

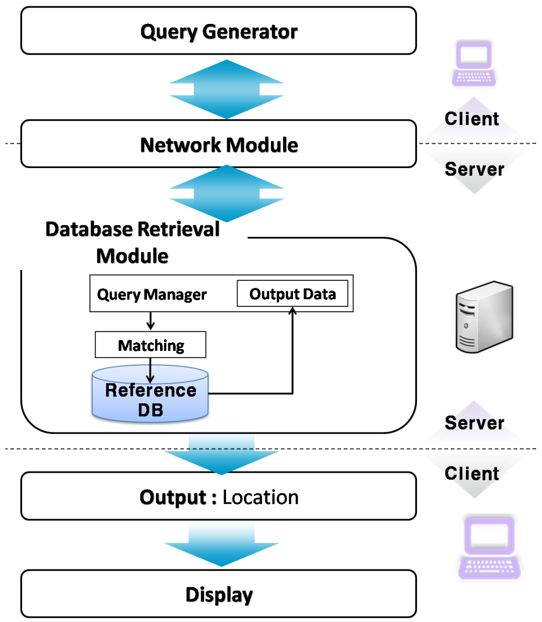


Figure 9. Network and Database Retrieval module of Indoor space geocoding architecture

manager checks validation of the queries, and decides how to access the reference database. Also, it searches tables and each record of them in the reference database, and receives attributes based on queries. During the retrieval, full matching, partial matching and manual matching are performed based on the matching process algorithm. In order to create queries based on each matching, the interaction among the query generator, network module and the database retrieval module are considered. Finally, if the output data is found through the database retrieval module, the location is displayed through an interface based on various visualization methods.

4.2 Experiment and Analysis

In this section, a viewer program is implemented based on the indoor space geocoding architecture. The indoor space of a sample building is visualized as three-dimensional footprint. Also, the query using related search terms is implemented. Furthermore, the indoor space geocoding is analyzed quantitatively based on matching rate and location estimation time.

4.2.1 Viewer Program

The building for this study is COEX, which has a largest underground mall and convention centers on the ground. Three floors from the first basement level to the second floor are the range for visualization as shown in Figure 10.

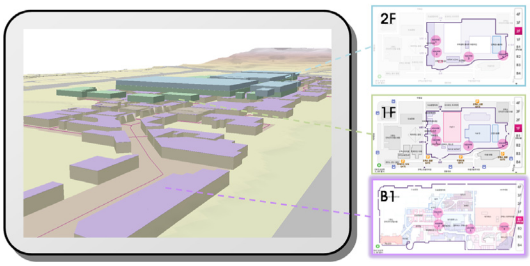


Figure 10. Case study area

The viewer program is developed as an application program based on Android OS, and OpenGL is used for 3D visualization. For the OCR engine, an open source Tesseract[20] is used, and the viewer program is developed based on an open source OCR android application[1], which contains the user interface for the use of the Tesseract. The interface for the recognition process, has a bounding box which limits the range for recognition and can be resized by users. Descriptive data is captured using equipped camera in a smart phone as shown in Figure 11(a). Refinement and classification of text are automatically done, and matching process is also performed automatically. However, for the manual matching, a user inputs directly text using a keypad and selects one of lists in auto complete textview as shown in the right side of Figure 11(b). The reference database for the matching process is created based on MySQL, and in order to generate SQL queries, PHP is used.

Footprints for each floor are firstly produced as two-dimensional polygons using A eGIS Desktop by ESRI. Seo-ddly, all points composing the polygons are ext Seoed, and the firropriate height

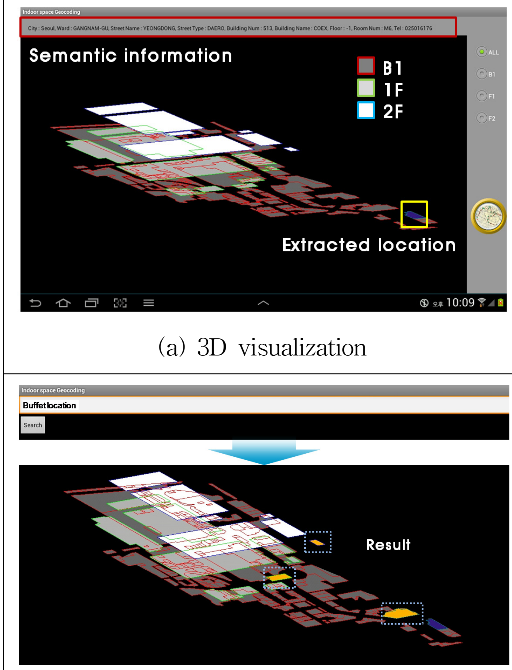
(a) Capturing descriptive data

(b) Manual matching using a keypad

Figure 11. Descriptive data and manual matching

value z is assigned to each point. In this study, a height of 5m is assigned on each floor. Finally, the coordinates x, y, z of all points are tt vs-formed into ASCII text file for 3D visual Iext fi using OpenGL.

The resulting location is represented as a different colored polygon from any other polygons, and the semantic information about the polygon as shown in Figure 12(a). For the application of this study, the query service using related search terms is implemented based on the viewer program. Related search terms based on types of business are entered, and the result is represented on the 3D visualization view as shown in Figure 12(b). In other words, users can find restaurants, shoe stores, cloth stores or cosmetic shops with the blue colored result location. For example, in the case of restaurants, users can find Japanese restaurants, Korean restaurants or Chinese restaurants typing the related search terms.



(a) 3D visualization

(b) Query service using related search terms

Figure 12. Viewer program based on Indoor space geocoding architecture

4.2.2 Analysis

Matching rate targets the three kinds of descriptive data as shown in Table 2. A total of 108 samples are tested for English business names, 65 samples for Korean business names, 101 samples for room numbers and 10 samples for phone numbers. Except for manual matching, full matching and partial matching are considered for automatic matching, and matching rate is estimated as a percentage. As a result, the highest percentage of matching rate is in the case of phone number, and the lowest one is in the case of the Korean business name.

Table 2. Matching rate of Indoor space geocoding architecture

	Business name		Room number	Phone number
	English	Korean		
Sample	108	65	101	10
Matching rate(%)	82.41	67.69	86.14	100

Although the number of phone number samples is relatively too low, the reason matching rate of it is 100% is because it consists of a simple combination of numbers. In the other hand, atypical Korean fonts on signs cause decline of matching rate of the business name in Korean language. Also, although the Tesseract, which is responsible for the core part of the character recognition, has high recognition accuracy, unmatched situations can occur because of randomly skewed characters, the effect of illumination or background color and pattern. Consequently, considering three kinds of descriptive data, correctly identifiable rate of locations in indoor spaces targeting a total 124 samples is 94.35%.

Location estimation time of indoor space geocoding architecture is represented as shown in Table 3. Processing time of indoor space geocoding architecture is measured based on the time taken from recognition process to extraction of coordinates. An average time is 1.58 seconds, 1.21 seconds for minimum time, and 3.39 seconds for maximum time.

Table 3. Location estimation time of Indoor space geocoding method

Processing time(sec)	Minimum	1.21
	Average	1.58
	Maximum	3.39

To sum up, advantage of this study is simple positioning using descriptive data based on geocoding method. In other words, the descriptive data is easy to be obtained in indoor spaces and the positioning process is computationally simple because of the geocoding method. Also, compared to other indoor positioning techniques, positioning accuracy is not variable since proposed method does not use radio frequency for positioning. However, proposed method is highly affected by performance of applied OCR engine during the recognition process. In other words, misrecognition caused by illumination or many different fonts occurs.

4. Conclusion

A geocoding method in indoor spaces based on character matching was developed in this study. Character recognition technique was applied to extract text data from descriptive data, and parsing and matching methods were proposed for the character matching. Also, in order to extract coordinates in a reference database, address point matching method was applied. In the parsing process, the methods of refinement and classifiso, in were proposed for standardizing and classifying text data in order for matching process. And for the autor toc matching process, three kinds of matching methods were proposed, and those are full, partial and manual matching.

For the implemento, in, indoor space geocoding architecture was designed based on the geocoding method using character matching. Input module, refinement module, network module, and database retrieval module were proposed as compositions of the architecture. Furthermore, a three-dimensional viewer program was developed based on the architecture as an Android application using OpenGL. The program used Tesseract OCR engine, and a query service using related search terms was implemented for the assessment of utilization of the architecture.

For further research, additional researches on the improvement of character recognition with stable and high accuracy are required. Also, since descriptive data acquisition occurs from storefront signs or room number signs, the errors caused by various fonts, illumination, and background color and pattern should be eliminated for following researches. In addition, for the extension of this study, 3D network model can be applied to provide location based services such as optimal route finding, directory services or advertising services.

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