Dissertation of Final Year Project

An Android based XJTLU campus tour system
—— XJTLU Maps

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Content

Abstract

A main motivation in this project is to complement some common drawbacks of global navigation applications for a limited scope. As the integration, XJTLU Maps is an android application that is configured to locating and navigating users in XJTLU campus. In order to improve user experience, the concepts of augmented reality and user-friendly presentations of the screen have been involved as well. Respectively, the function of locating is realized by a mapping mechanism between a raw image and a coordinate system of android platform; for augmented reality, a series of photos are settled to represent every entrance of every buildings, and switch operation is based on touching screen; a backtracking analysis approach serve as a logical module for navigation event that outputs an optimal route according to users' input; user-friendly presentations of the screen includes moving, zooming on and out by invoking some methods from Matrix. Moreover, an evaluation concludes that the current realizations in XJTLU Maps fulfill basically the items of specification and design.

Keywords: XJTLU Maps, XJTLU Campus, android application, small-scale scope, locating, navigating, augmented reality, user-friendly presentations of the screen.

1. Introduction

Android as a prevalent platform in current smart phone market furnishes Location-based services (LBS) for tracking and navigating. With the brisk phenomenon, many applications (e.g. Google Maps and Baidu Maps) have further expanded and enriched this function to be more user-friendly. However, one situation that should be considered is whether these navigation applications are informative enough for limited scope of target areas such as in university campuses. Based on this premise, there are two main challenges as following: (1) a majority of small-scale facilities (e.g. tennis courts, coffee shops and parking lots) are not properly shown in global navigation applications. (2) Global navigation applications are not sophisticated enough to deal with timely information — refreshing the information of physical building environment must be treated to be a crucial part for a virtual campus tour service. A former research [1] maintains the same perspective that global navigation is not amply available for the campus navigation. To address this problem, the project customized Google Map by uploading location data of custom map (an XML file) to MySQL server and spreading the updated information with the support of Near Field Communication (NFC) technology.

In relative terms, this FYP aims to construct a navigation application of Android platform without using Google Maps or Baidu Maps it focuses on the target population who plan to recognize and travel the university campus of Xi'an Jiaotong-Liverpool University (XJTLU). In the process of development, some innovations and complements may be infused in this project than some relative products. From technical aspects, the objective can be approximately divided into several parts to achieve:

- User interfaces should seamlessly fit into the functions that this application supposes to realize, and user-friendliness could be incarnated in the process of operations.
- Server and database are anticipated to be responsible for updating timely

information and displaying processed maps separately.

- Statistical analysis could be used to map the data of LBS to an accurate spot into the raw map of XJTLU.
- After analyzing XJTLU campus maps, the result could be developed to arrange reasonable routes over the overall campus. Finally, highlighting the shortest path between two settled spots through the Dijkstra algorithm.
- When equipment problems influence the effect of location information's reception, artificial intelligence and machine leaning technologies could be used to estimate approximate route of customer through analyzing former movement tendency of this person.

2. Relative work

When an application intends to launch on the market, it should ensure that any user can apply the overall functions with disparate backgrounds. Matching taken pictures of actual public maps with the maps in database [2]. Which is a hazardous manipulation can induce some limitations for this application, because of the exorbitant requirements to users and mobile devices. Therefore, this application will avoid involving some functions to the greatest extent that would cause discrimination between users.

The navigation function of this project simply overlays some augmentations on the navigation maps that have already existed in database, and the result restrains some subsequence developments to some extent. There are some advanced projects with the different implements of landmarks and sights: Warping the angles of images and a 3D model for captured scene [3] that indeed improved sensorial recognition for users. On the other hand, a majority of maps in this application belong to the attribute of an aerial view, so the performance of this approach is feeble for this application. As for navigation data model, LPNMD [4] maintains landmark salience is usually neglected for most of models, but this situation aimed at that some complex indoor and outdoor

context in the process of pedestrian navigation. To sum up, though these advanced researches perfect the details of navigation function, their target population and implement purpose focused on a deflected angle than this application. At a higher degree of development, this application will consider to emulate.

Admittedly, some advanced technologies in configurations will certainly buttress the development of this project. For instance, the drawbacks of network will possibly be encountered during execution, and this is an incapable encumbrance in the field of hardware. With the development of technology, Received Signal Strength [5] and CDMA Cellular Systems [6] will promote this application to be more robust in the future.

As for the correlation of others fields, it is significant that this research can be further explored to various modalities. Take one for example, Remote open Campus System [7] allows remote users to monitor and operate robot clients' behaviors by capturing campus maps and achieving event information. However, robots must obstinately reach all specific check points that are already planned during execution. Based on considering the situation of missing data (a fragmentary picture is obtained by robot, or a check point is moved), a revised implement can refer the predictive features of this project.

3. Project Design

3.1. Use case diagram

Fig 1 presents a use case diagram for this project, and it embodies a sequence of behavior and interaction of user during execution of this system. The hierarchy of software components can be bifurcated into the view of the server and the view of the client: an important requirement for the server is that a batch of information can be duly updated to database. This content is a combination of alteration of maps and that latitudes and longitudes of barricades. Regarding to the operations of the user,

navigation function should involve the sustainment of user location and target area, and the version of augmented reality can be extended by user requirements.

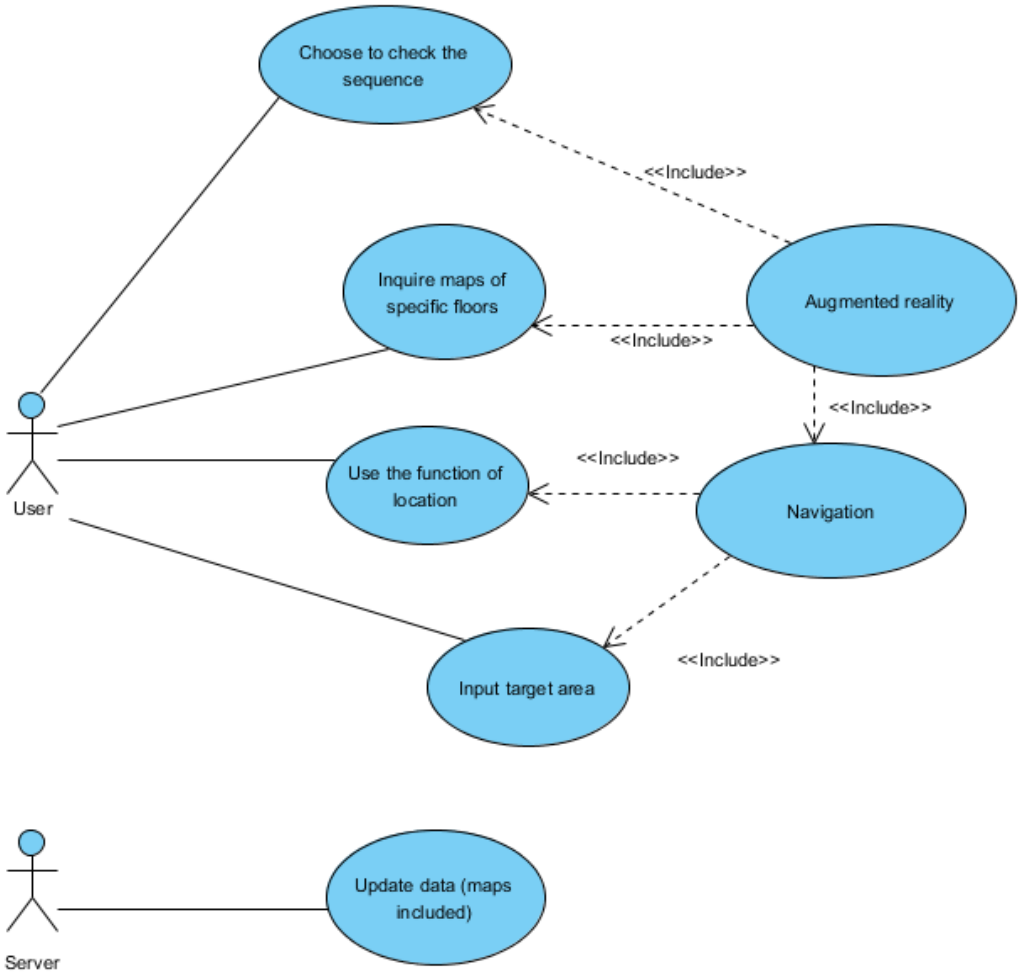


Fig 1. A use case diagram.

3.2. Location Algorithm

The accuracy of location data is completely deemed as a most important criterion to determine whether this application can realize the further demands, and hence a chained method was proposed for reducing loss of information. When users transform application scenarios from outdoor to indoor and vice versa, a message of location change will be triggered by event listeners, and these event listeners can track the status of GPS, network and base station. The order of execution is settled as following: Firstly, adopting GPS to locate. If GPS is disabled, cell phone will automatically

invoke network. If network is also stymied, base station is available. GPS can locate user's location with more precision and speed, which is main reason why GPS is preferential in this logic. However, the technique of GNSS [8] still suffer from indoor environment cannot be reached, and a more recent research [9] has unveiled that GPS has some opposite disadvantage than WLAN. According to this limitation, network will be suggested to serves as a substitution after GPS.

3.3. Algorithms in optimized paths

After a general browse of mainstream navigation applications, it is obvious that the majority must firstly extract all possible routes between an initial point and a target point. After analyzing and comparing some crucial factors of these routes, a most germane route will be considered to use. This project still adheres to the sequence of aforementioned operation, and this user interface (fig 3.) below principally carry out location and navigation based on customizing and deploying all paths in the XJTLU campus map. As shown, that red circles and yellow circles are settled and labeled over every path can provide navigation information for optimization. Respectively, each red circle represents an entrance at one side of one building where are usually used to serve as target areas in navigation routes, and yellow circles in interlaced paths are considerable situations that can judge which orientation should be selected. In the SQLite database of this application, every circle (both colors included) is described with the location data of center and a radius of 5 meters. In other words, if discerning that the latitude and longitude of a point appear inside the scope of 5 meters (based on a center), this location will be designated to the relative circle in navigation design.

Fig 3. Net routes on the XJTLU campus map

An algorithm would be utilized to gauge which circles are the transit areas (yellow circles) after confirming the starting point and the destination (red circles) of a navigation event. After much deliberation, it is necessary to derive a judgment method (algorithm 4) from the concept of Breadth-first search:

algorithm 4

```
1   Input∆: the latitude and longitude of starting point; the latitude and
2                 longitude of target point; a[ ] with all recent X points.
3   Output∆:   b[ ] with selected points.
4   index1 ← 0
5   for index2 ← 0 to X do
6   begin
7         if ( a[index2].latitude == starting point.latitude )
8               and ( a[index2].longitude == starting point.longitude ) then
9               b[index1] ← a[index2]
10        if ( a[index2].latitude == target point.latitude )
11              and ( a[index2].longitude== starting point.longitude ) then
12              holdTarget ← a[index2]
13  end
14  if (b[index1] == null) then
```

```
15      begin
16        report: the starting point is not close to any circle in the scope of 5m.
17          // invoke algorithm 5 and acquire closest point.
18          b[index1] ← algorithm 5 (starting point)
19          end
20  if   (holdTarget == null) then
21       begin
22       report: the target point is not close to any circle in the scope of 5m.
23          holdTarget ← algorithm 4 (target point)
24          end
25          order ← index1 //this point has already been considered.
26       while ( b[order] .latitude != target point.latitude )
27                and ( b[order].longitude != target point.longitude ) do
28              Begin
29          if b[index1] has only one near point then
30                begin
31                      index1 ← index1 + 1
32                b[index1] ← the near point
33                end
34              else
35          while b[index1] still has one near point do
36             begin
37    if ( |b[index1].latitude - holdTarget.latitude| <= |b[order].latitude -
38       holdTarget.latitude|) or ( |b[index1]. longitude - holdTarget. longitude|
39    <= |b[order].longitude - holdTarget.longitude |) then
40            begin
41                index1 ← index1 + 1
42                b[index1] ← the near point
43          end
44        end
```

```
45          order ← order + 1
46      end
```

As algorithm 4 presents, in order to precisely induce users in a navigation route, a common exception is that the user exceeds the scope of all circles (both colors included). In the execution of Algorithm4, Algorithm 5 would possibly be invoked to index closest circles or provide constructed circles in the paths of XJTLU campus map.

algorithm 5 (a location)

```
1     Input△:    a location X with latitude and longitude.
2     Output△:   a point Y in the paths.
3     Set X as a center, and circleScope means the radius of this circle (meters)
4           circleScope ← 0
5       while Y is not found out do
6      begin
7             circleScope ← circleScope + 3
8        if one path with one intersection in this circle then
9                 begin
10                   Y = this intersection
11                   finish
12                    end
13      if more than one path in this circle then
14                begin
15       Compare these paths, and then the closest one will be selected with
16    intersection A and intersection B.
17      if ( intersection A. latitude == intersection B. latitude)
18                      begin
19                      Y. latitude = intersection A. latitude
20      Y. longitude = (intersection A. longitude + intersection B. longitude)/2
```

```
21                  end
22              else
23                  begin
24      Y. latitude  = (intersection  A. latitude  + intersection  B. latitude)/2
25                      Y. longitude  = intersection  A. longitude
26                  end
27      end
28              End
```

The above procedure can index the all possible routes in XJTLU campus map. If every path is labeled by a practical weight of distance in further research, a revised Dijkstra's algorithm would be assembled in this application to highlight the optimal route. Furthermore, the key distinction is that the revised Dijkstra's algorithm confines the backtrack search according to the scales of latitude and longitude.

3.4. Augmented Reality

Plenty of projects [10] [11] have revealed that augmented reality can subvert the limitation of local landmarks and sights in mobile maps applications. By a critique of this application itself, if navigation function is utilized to guide a XJTLU campus' novice who is inside a building now, it is obscure that all information is epitomized in an aerial view. Therefore, the further refinement of this project is planning to promote use experience by augmented reality.

At present stage, this project has already accomplished some foundations: user location can be precisely obtained, and a target point is successfully rendered to this application by input. It is on this premise that a series of maps can friendly navigate users with the concept of augmented reality. A scenario is presented below to elaborate details of operation: a student aims to the destination (the first floor in the Environment Building), and this application has identified the location on the 8st floor

in the Center Building. When this user applies navigation function via the user interface, some prepared (Fig 6, Fig 7, Fig 8 and Fig 9) pictures will be sequentially exhibited as follows:

Fig 6. 1st step, navigation on the 8st floor in the Center Building

Fig 7. 2st step, navigation on the 1st floor in the Center Building

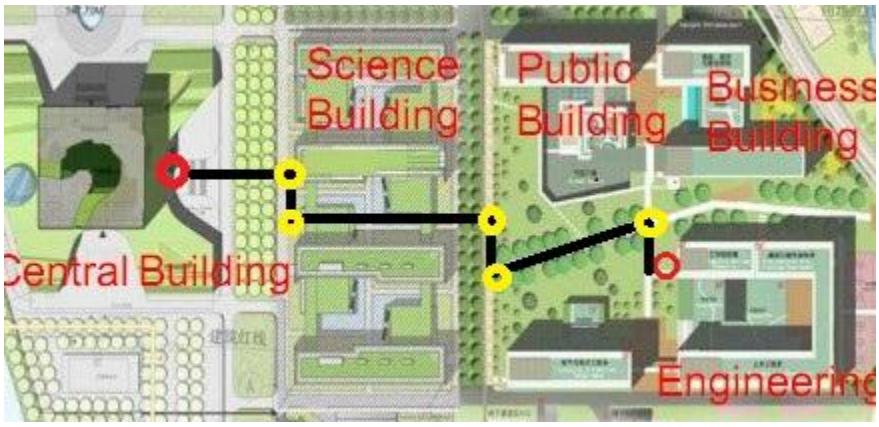


Fig 8. 3st step, navigation on the XJTLU campus map.

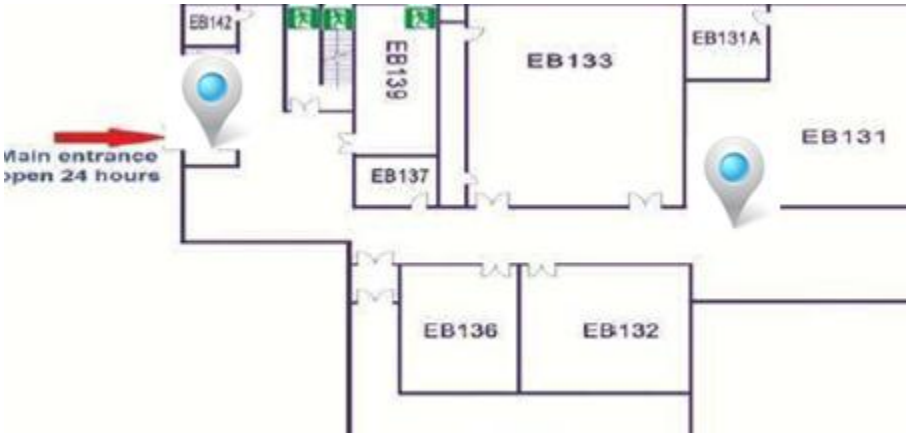


Fig 9. 4st step, navigation on the 1st floor in the Environment Building

There maps indicate visually all directional instructions by landmarks and lines, and each picture stands for a subtask should be follow. When users fulfill current behavior, the next one will be displayed by sliding the screen. To be practical, this application can configure the lightweight implement that improves comprehension of operation for users and alleviates burden of hardware.

4. Specification

4.1. Statement of Deliverables

All functionalities are encapsulated in an android application, and these manipulations are simple and convenient for users who dabbled in Android platform. Regarding to the anticipated experiments, algorithms are implement objects which will be judged for accuracy of location and navigation. In the every step of testing and debugging, Google Maps and Baidu Maps will serve as the control group to compare different results of same operations in this search. Furthermore, in order to estimate the adoption level of customer market, questionnaire of user experience will be conducted, and the items involve comfort-ability, usability, operability, impression, time and deviation.

4.2. Implementation tools

In order to avoid some slant data and incompatibility errors to happen, the testing instruments must have a different screen size and a different Android version on the premise of successful execution, and there are the contented tools as follows:

MEIZU MX2(cell phone) with 10.1 inches and Android 4.1.2.

Samsung GT-N8000(tablet device) with 4.4 inches and Android 4.4.4.

Programming platform is based on Eclipse (Android Developer Tools). SQLite Expert Pro will be utilized to visually manage the database. For undergirding the interactivity, this application can update timely change and achieve user information by Glassfish server.

4.3. Schedule and milestones

As things stand, the function of getting user location has been completed, and a corresponding spot can be pinpointed on campus maps of XJTLU. Subsequent research will mainly extend to path planning for navigation and better consummation for user experiment. The schedule allocates internal/external milestones of remaining research according to magnitude of problems (Fig 10):

Items (Internal/external)	Begain date	End data
Deploying all route in maps (external)	12/10/2014	12/31/2014
To study algorithms for Optimized Paths and Augmented Reality (internal)	01/01/2015	01/31/2015
Completing all functions of navigation in app (external)	02/01/2015	02/15/2015
Testing and debugging (internal)	02/16/2015	02/28/2015
Designing user interfaces to be more friendly (external)	03/01/2015	03/15/2015
Final refinement and further functions (external)	03/16/2015	03/31/2015
Final testing and debugging (internal)	04/01/2015	04/15/2015
Analysis and summary (internal)	04/16/2015	04/23/2015
Final Dissertation (external)	04/24/2015	05/18/2015

Fig 10. Schedule of Internal/External Milestones

The Gantt chart below presents relative duration times of the Schedule (Fig 11).

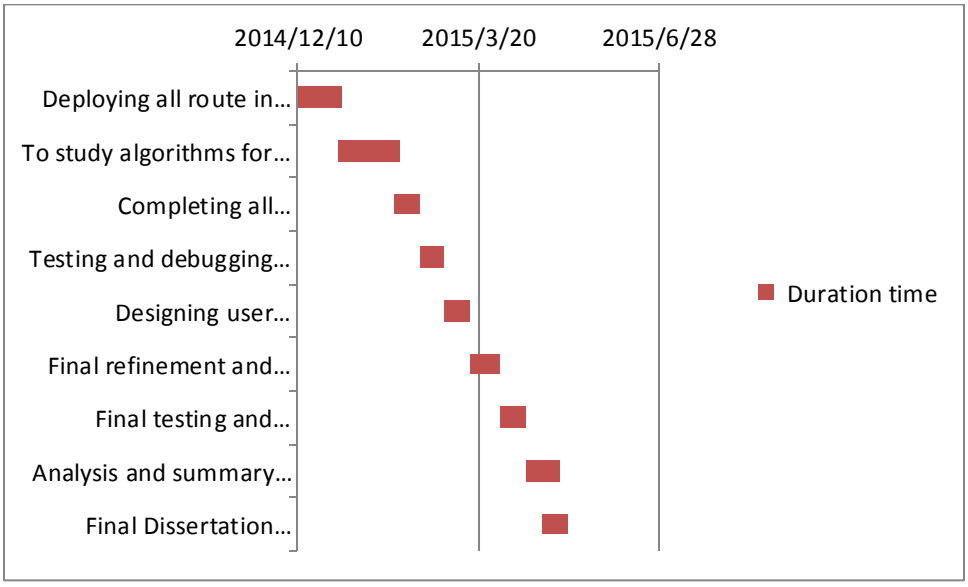


Fig 11. Gantt Chart of Remaining Research

4.4. Risk assessment

A main vulnerability may be caused in a situation that target maps do not accord with the fact. To be detailed, because of disordered scale in the XJTLU campus maps, relative sizes of buildings and distances between spots cannot be calculated to corresponding latitude, longitude and elevation. In addition, though all routes between buildings have already been deployed over XJTLU campus, numerous barriers probably exist in the space from user location to the routes, which would incorrectly navigate users to these unnecessary areas. For a directly solution, it is very arduous and miscellaneous that latitudes and longitudes of every item must be recorded in database.

5. Realization

A vantage point of analyzing this project is an implementation of that the integrated program is unraveled into several main achievements to remain a basic skeleton. For its outcomes, the revelation of skeleton is able to indicate explicitly how these functions interact with each other on the platform where the captured information of device is shared, and independence of individual functions maintains a logical orderliness from algorithmic conceptions to technological frameworks. In the construction of narration, a brief specification will firstly introduce some mechanisms of Android platform which are invoked to bolster following realizations, and then by considering visible embodiment of operations, these realizations will be divided into: (1) Location (2) Augmented Reality (3) Navigation (4) User-friendly presentations of the screen. The declarative manner attaches most importance to constitutive requirements of technology level and mingle some concrete user cases as objects. Furthermore, the unabridged program source codes and the detailed composition of SQLite data base that is dedicated in the navigation will be rendered in the appendix section.

5.1. Foundational supports of Android platform

Position sensors of most Android-powered devices are employed to acquire GPS information (consists of latitude, longitude, and latitude etc.) from the current physical environments, and the flow of execution is described as follows: it is an instruction triggers listening for the coverage of updates on cached data from the location providers that users implemented a specific piece of code by starting a activity in the application, and a filtration will process to optimize an estimate of the location. In XJTLU Maps, GPS_PROVIDER is utilized to judge whether the position a device situates is indoor or outdoor when the user enters this application, which decides a subsequent implementation is in the method displayOldLocation() that procures last known condition through the GPS data of this time point, or in the method displayNewLocaion() that real-timely refurbishes geographic coordinate information with tracing the tendency of the moving user. As acquisitions, the data of latitude and longitude transmits to the class DrawView by declaring an apropos object for the accurate arrangements of coordinate points.

Android platform maintains a coordinate system in the expression of graphical interfaces, which aims to establish a referential standard in order to deploying widgets on screen. Throughout the range of visualization, top left corner of the screen is designated as the original point that dominates a right extension to be X-axis and a under extension to be Y-axis in units of pixels. By practicing this theory in some samples, it is a ponderable in the arrangement of graphical elements that normal devices must distribute the corresponding space of the coordinate system's periphery (inside the screen) to status bar and title bar. Considered the implementation tool of this project as an example, Sumsung GT-N8000 (1280*800) partitions the idleness of 255 pixels and 75 pixels to width and height respectively, which equates that the remaining utilization is confined to an enclosure of 1025*725.

5.2. Locating

As a premise, it is ineluctable in this project that accuracy of resources is able to fluctuate in the performance of application to some extent. For undergirding follow-up development, the dispositions of resources were dedicated as follows: In Figure 12, an underlying map layer was established by resizing a raw JPG format picture of XJTLU campus with 1792*855 to cater to the scope of 1025*725 in the coordinate system.

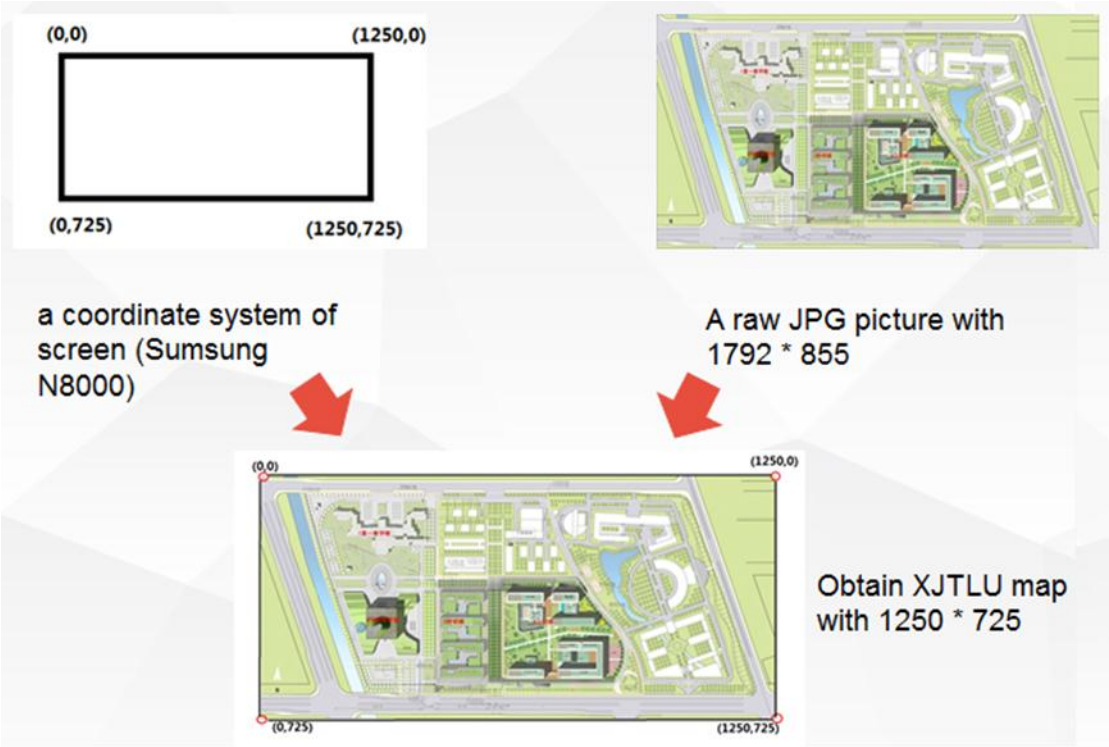


Fig 12. Fusion of Coordinate System and Picture.

According to the defined map, manual detection had been conducted to measure optimal geographic information of four vertexes while the device was constantly aligning the located positions in physical surroundings, and the results were recorded with a clockwise direction of the map:

Vertex 1(Longitude = 120.73144455049008, Latitude = 31.27759898214914);

Vertex 2(Longitude = 120.7316831132832, Latitude = 31.273418001173557);

Vertex 3(Longitude = 120.7422018433988, Latitude = 31.2738074697868);

Vertex 4(Longitude = 120.74122940503344, Latitude = 31.27807651457051);

Based on confirmation of above cornerstones, a chief superstructure needs to realize function of locating through a projection from GPS data to fixed points of screen. Therefore, a logical adapter should be responsible for the conjunction; an algorithm garners latitude and longitude of positions as inputs and produces X coordinate and Y coordinate of points as outputs. Corresponded to the appropriate executions in programing, the public class myTran serves as such a pivot by endowing interactive operations with declared objects of application classes. In order to match with a concrete mark on the map of XJTLU campus, the distances (expressed as longitude and latitude) from recent captured position to vertex 1 severally multiple by the numbers of pixels each degree of longitude and latitude occupy which are calculated by two ratios of that the height and width (defaults to 1025*725) of the coordinate system to that a longitude difference of vertex 3 to vertex 2 and a latitude difference of vertex 4 to vertex 3. The algorithm 13 can be normalized as pseudo codes:

Algorithm 13 (myTran)

1 Input∆: a longitude data LONGITUDE; a latitude data LATITUDE; POINT1 is the top left corner of map; POINT2 is the bottom right corner of map.
2 Output∆: a value X of x-coordinate; a value Y of y-coordinate.
3 VALUE1 ← Vertex 3.longitude – Vertex 2.longitude
4 VALUE2 ← Vertex 4.latitude – Vertex 3.latitude
5 RESULT1 ← (POINT2.x –POINT1.x) / VALUE1
6 RESULT2 ←(POINT2.y –POINT1.y) / VALUE2
7 DISTANCE1 ← LONGITUDE – Vertex 1.longitude
8 DISTANCE2 ← Vertex 1.latitude – Latitude
9 X ←POINT1.x + DISTANCE1 * RESULT1
10 Y ←POINT1.y + DISTANCE2 * RESULT2

When the pertinent output is returned to the class DrawView, a salient red icon on the picture deputizes the location where the user is situating in XJTLU campus. With the

dissimilarity of that View is used to display static images, the class DrawView iterates a method onDraw() to simulate the dynamic characteristic of animation for the visual experience of users through extending a superclass Canvas.

5.3. Augmented Reality

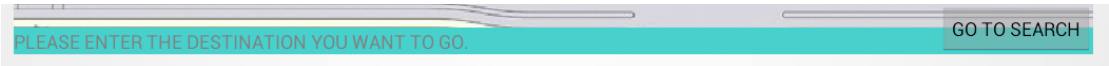
Even though the function of locating foregrounds that the comprehensible ichnography can detract the dependence of realistic environment by vivid depictions and verbal annotations, a complementary calibration still fetters users to tautologically scrutinize precision of the connection. With regard to aftermaths, user experience will be not merely diluted continuously in the process of redundant operations, but a concealed damper will incidentally occur to withhold efficiency of this application when some users do not possess a perceptive discernment or are in a somber surrounding. Due to this consideration, the concept of augmented reality is allocated to seamlessly integrate factual information and virtual information in XJTLU maps, which is conductive to facilitate the feedback of a reflection from germane entities that users should trudge to experience. As shown in the figure, there are a series of sedentary thumbtacks are used to symbolize the entrances of every building. When the projective screen region of a distinct thumbtack is involved as the activation by users' physical contact, an event is aroused to superimpose a relevant image with the resizing of about 245*245 pixels on the screen. A monitoring mechanism stipulates only single touch can switch execution states of the realization of augmented reality; users view a tandem of images by clicking successively, but concurrency is impermissible on account of preventing a chaos of multiple representations and a inconsonance to other functions. Similarly, it is a situation revokes this operation that users replace a trigger point outside the scopes of these thumbtacks. From a technical perspective, single touch is listened by the aforementioned method onTouchEvent(MotionEvent event) that is able to acquire positions of the screen with a format of the coordinate system. Mated with the number of these given thumbtacks, commensurate if statements are used to judge severally whether current motion event

of single touch falls within any corresponding scope into the thumbtacks. The condition of each if statement is defined as a demarcation that expands four orientations (up, down, left and right) with a interval of 25 pixel from the specific thumbtack.

Fig 14. Fusion of Coordinate System and Picture.

5.4. Navigation

For a majority of target customers, navigation is the most pragmatic configuration in XJTLU Maps to respond the anticipatory purpose of this project that devotes to guide novice users in XJTLU campus. A rudimentary conception is that a shorted route is elicited by logically addressing users' current position and search input value. Anatomically, the overall realization of navigation can be metamorphosed to be an application flow that is coalesced by requisite elements in a chronological order, and these individuals are untangled into: (1) searching values from users' typing: Reciprocally, a stable interaction between users and XJTLU Maps guarantees the autonomous right of users and augments the diversity of this application. As a preliminary step, the input field of Figure is outfitted to empower users with the selection of triggered events based on Android Widget.



(2) A button calls an adapter: After users click the button of Figure, a current string will be converted to upper case and only intercept the first two characters as input to

convey to a specialized utilization of adapter pattern. (3) Adapter confirms optimal target. For the sake of debugging in the process of development, the initial version of XJTLU Maps merely permitted users type some specific strings which must comply with the values of the attribute “DESCRIBE” of established SQLite database (reference in appendix). However, it is tactless for amenity of the product that uses were restricted to grasp these slight data for appointing a thumbtack as the destination of an indexed route, even an optimal schema was not winnowed. Adapter pattern of programming design was dispatched to redeem this disadvantage; as shown in the Figure 15, a created class assumes the responsibility of an adapter between MainActivity and myDatabase to carry out the retrieve of earnest destination. Particularly, all entrances XJTLU Maps deploys should be clustered into units of buildings, which entails that subsequent user inputs can externally specify the logogram of a building to be a keyword. With the bracings of the data of current position and the search input value, the class Adapter filters out an optimal entrance as destination by comparing the distances from current position and all entrances of the building on the screen. Respectively, the GPS data of current position derive from the declaration of object, and the attributes “LONGITUDE” and “LATITUDE” of SQLite database are accessed to achieve the values of longitude and latitude of these entrances pursuant to relevant mappings in the attribute “DESCRIBE”. After that, the result will be transferred to the class ViewDraw through a parameter of the callback to the class MainActivity.

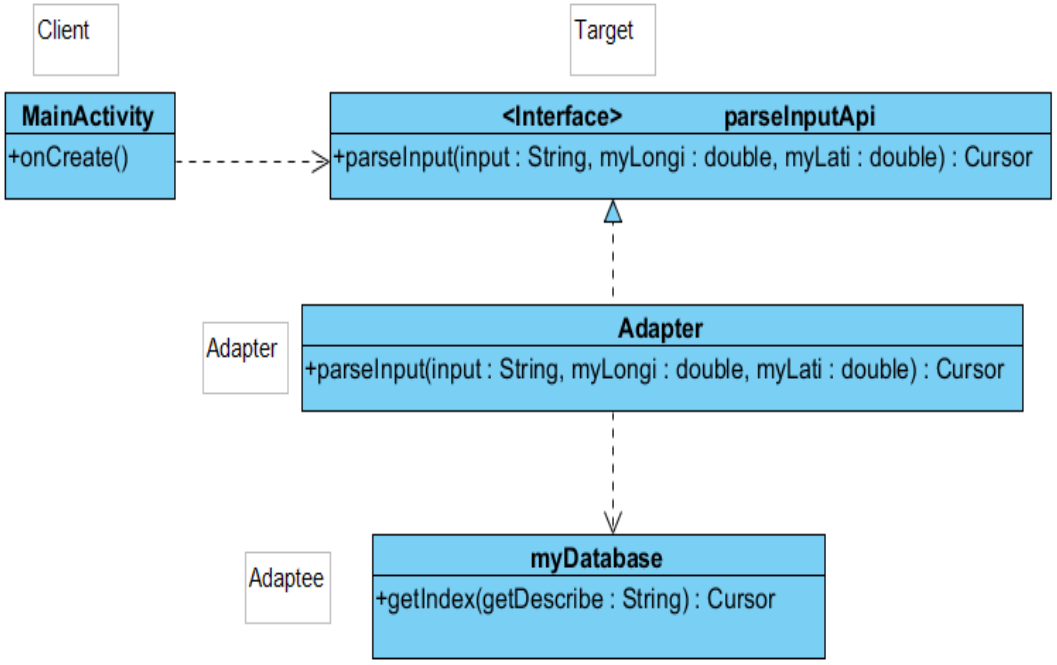


Fig 15. A class diagram about the adapter pattern.

(4) A chain of road signs is labeled as the route: The procurement is equivalent to a sanction of the navigation event for the destination, and it steers the state of all road signs which are equipped to induct users with a manner of user-friendliness. Specifically, the class ViewDraw rummages again the database to export the value from attribute "LINK" of the destination, and this attribute is in charge of recording a collection of road signs which link to an objective (could be an arrow or a thumbtack) through a relationship of adjacency in XJTLU Campus. After splitting the data of "LINK" by notations, the parsed items are respectively used to measure distances to the physical location the user is in, and the minimum as result of a series of comparisons is flagged to be a new objective in next recursion. By looping, until it is satisfied that the distance from a road sign to current position (red mark) is less than any distance from adjoining road signs of the road sign to itself. At this moment, the whole navigation event is digitized to be an array to store orderly a thumbtack as the destination and a succession of road signs as road signs, and the attribute "REVEAL" of these road signs are switched to "N" in the SQLite database. (5) Adjusting the direction of the road signs: in order to disabuse users' bewilderment about mutable

orientation of a selected route, it is a significant criterion to arrange all road signs on the map that there is an intersection users have a potential opportunity to swerve. Regarding to the practical realization in this program, an image of affixing arrow stands for road sign, and a logical judgment (algorithm 16) is utilized to rotate the angle of these arrows.

Algorithm 16 (Angle)

```
47 Input∆: the array display[ ] with a destination and a chain of road signs in order.
48 Output∆: each road sign is with a corresponding integer as value of angle.
49 X ← the number of road signs
50 for Y ← 0 to X do
51 begin
52        A ← |display[Y].longitude – display[Y+1].longitude|
53        B ← |display[Y].latitude – display[Y+1].latitude|
54        if (A >= B) then
55                  begin
56                  if (display[Y].longitude >= display[Y+1].longitude) then
57                  VALUE ← 270
58                  else
59                  VALUE ← 90
60                  end
61            else
62                  begin
63                  if (display[Y].longitude >= display[Y+1].longitude) then
64                  VALUE ← 180
65                  else
66                  VALUE ← 0
67                  end
68 end
```

As listed in the algorithm, the angle of every arrow is restrictedly assigned into 0°, 90°, 180° or 270°, which echoes to a consideration that presentation of accurate angle is too trivial to blunt conciseness of the underlying map. A for loop traverses the attribute "REVEAL" of all tuples of the SQLite database to dichotomize thumbtacks (defaults to "N", and will be not altered) and arrows (defaults to "Y", but can be altered to display) into two updated clusters "Y" and "N", and then the cluster "N" (included all thumbtacks and the labeled arrows) is ratified to be visible. So far, the optimal route can be embodied by displaying a concatenation of the thumbtack and the angled arrows. (6) The thumbtack and arrows are revealed with an effect of flashing: even if the introduction of arrows is originally ponder to hammer at an index of the optimal route, a region with dense thumbtacks still catalyze a turmoil to users' recognition for the target destination. As a solution, an effect of flashing highlights a thumbtack and a chain of arrows for emphasizing the component route and eliminating an interference of the other thumbtacks on the map. From a technical perspective, because of sustainability of a mechanism that every replacements of GPS data for users' current position needs to refresh the method onDraw() in the class ViewDraw, it is feasible to achieve the effect that all elements in the array are represented on canvas with a luminance parameter that decreases progressively until to be 0 and turn back to 100.

A scenario (Figure 17) is cited to explain the logical framework of this function. When a user is in "FB1" and inputs "SB" as target value, the search scope is limited into all entrance (i.e. "SA", "SB", "SC", "SD", "SAPB" and "SDEE") of Science Building. As listed in Figure 18, data of LATITUDE and LONGITUDE of each entrance will be elicited to compare respectively the distance from itself to recent position (i.e. red mark). After calculating, the nearest entrance "SDEE" is labeled as destination of this navigation event. At this moment, the attribute LINK of "SDEE" is retrieved to obtain which arrows have a direct link to "SDEE", and then arrows "1", "3" and "15" as results are inputted to next calculation for getting a nearest arrow (i.e. "15"). By parity of reasoning, "16" is labeled from "1", "3", "14" and "16" in the

LINK value of “15”; “21” is labeled from “15”, “17”, “21” and “23” in the LINK value of “16”. Until every linked arrow of “21” is used to compute a distance that is less than the distance from “21” to red mark, and the all pivot can be orderly confirm into “21” → “16” → “15” → “SDEE”. In addition, the arithmetic Angle will rectify direction of “21”, “16” and “15”.

Fig 17. A scenario of navigation.

ID	LONGITUDE	LATITUDE	REVEAL	LINK	DESCRIBE
33	120.7349898	31.27556786	N	3, 7	SA
34	120.7350274	31.27514893	N	3, 7	SB
35	120.7349965	31.27464488	N	3, 7	SC
36	120.7350587	31.27420174	N	2, 3	SD
31	120.7361264	31.27424258	N	1, 3, 15	SDEE
15	120.7361629	31.27469791	Y	1, 3, 14, 16	15
16	120.7371454	31.27484693	Y	15, 17, 21, 23	16
21	120.7387826	31.27496598	Y	1, 18, 22	21

Fig 18. A segment of SQLite database about the scenario.

5.5. User-friendly presentations of the screen

As things stand, a watershed behind the above realizations has almost fulfilled general requirements of a mapping application. Nevertheless, the testing of these functions was merely conducted by a big-screen tablet (Sumsung GT-N8000 with 1280*800 pixels), which causes neglecting user experiment of mobile phone users to some

extent. There is a probability of tapering the portion of user population; when the details in map are obscure for mobile phone users, they may be subliminal to spurn. Intuitively, a coping strategy is that users are vested a permission to resize and move the map on screen without relinquishing the exactitude of other operations. As a prospect before implementation, it is an adjunct was planned to boost the completion of this function that screen can automatically focalize the scope based on a calculated central point after user performed the operation of zooming in or out. However, the specific implementation is byzantine due to an involvement of tracing coordinate system. By considering, an expedient is designed to complement this realization: In terms of the method onTouchEvent(), the class DrawView is able to monitor Pinch-to-zoom as an event of resizing and Slide-to-move as an event of moving. As sketched in the left side of Figure, the pinching behavior from users is digitized into coordinate data of two starting points and two ending points. Through the force analysis in figure 18, the data are mapped to material displacements of X-axis and Y-axis for calculating a relative scale than the proportion of entire map. Subsequently, the outcome is fetched to work as a parameter in a method postScale(), and this method is a build-in transformation of android.graphics.Matrix that dedicates to resize an image object. It is simpler in Slide-to-move that the distance of sliding is decomposed into a horizontal value and a vertical value, and channel into a method postTranslate() to reflect the behavior on screen with same mechanism at postScale(). With regard to this project, completion of the accessory should guarantee whether the performance of arterial functions is not fluctuated to a certain degree; with the alteration of map on the screen, relative positions of thumbtacks and road signs are invariable. For purpose of espousing the comprehension, coordinates of four vertexes of the map are trace by claiming four point variables which are then assembled in all objects of the class myTran. In addition, a series of assorted mechanism is supplementary to confine the range of change (included maximization, minimization, and moving region) based on a consideration that users have a leeway to recuperate some missteps during these gesture operations.

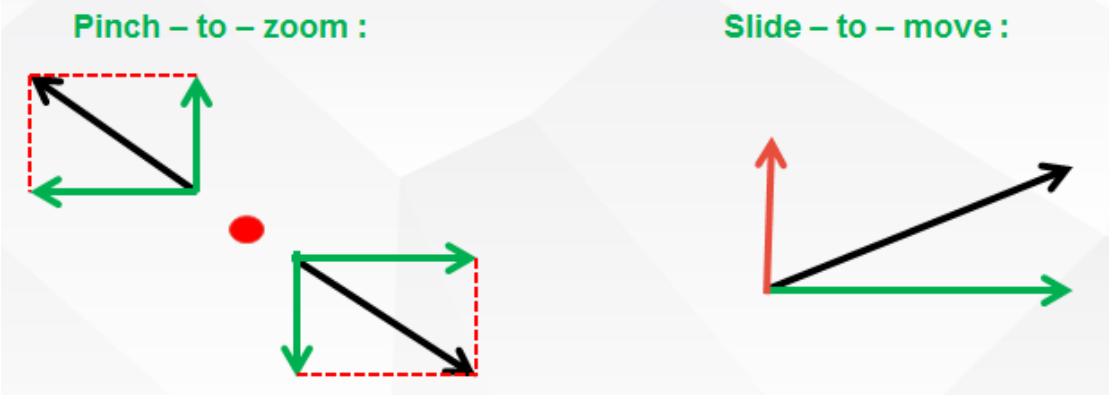


Fig 18. Force analysis on zooming (left) and moving (right).

6. Evaluation

6.1. Testing

Software testing is an active procedure to verify and confirm the quality of a product throughout entire life cycle of the software. This chapter provides an overview to deliver testing results by consulting standards of four testing models: black box testing, white box testing, integration testing, and system testing. For disparate intentions:

- Black box testing is used to externally detect whether each function in XJTLU Maps is eligible to crutch concrete realization.

- White box testing is configured to internally dissect all algorithms in XJTLU Maps for ensuring that these are not logical vulnerabilities.

- Integrating testing is utilized to construct a certain amount of subsets which combine two or more individual functions for maintaining the compatibility of interactions.

- System testing is allocated to conduct an experiment which yokes the software XJTLU Maps, the peripheral equipment and the procurement of GPS to be a main

system with a testing of performance.

6.1.1 Black box testing and Integrating testing

The function of resizing and moving the map and the function of navigation should stand on the ratification of locating, which is the reason why this section must blend black box testing and integration testing to fathom reliability of every function in XJTLU Maps. This testing was inaugurated by deploying five testing points in XJTLU Campus, and the Figure 19 shown the approximate position of these five testing points. Theory of this setting is a derivative from equivalence partitioning and boundary value analysis.

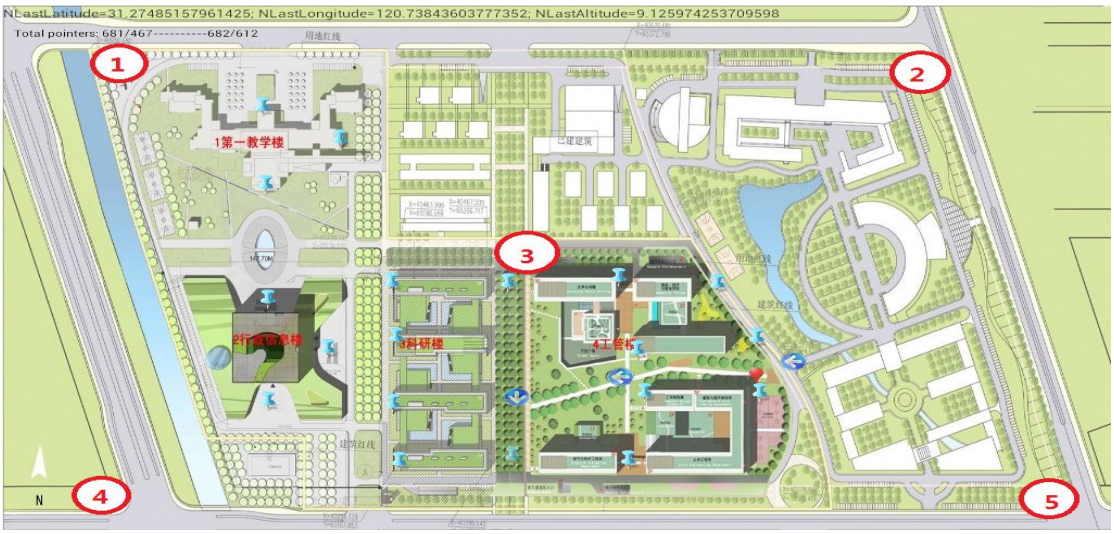


Fig 19. Five testing points

When investigator located in these five positions, specific test execution was scheduled as follows: (1) Surveyed the physical environment the investigator is in and the screen position the red mark recently exists for gauging accuracy. (2) Clicked all thumbtacks in the screen to ascertain whether all images match relevant entrances of buildings. (3) Carried out two operations that firstly zooming in the screen to the maximum limit and end zooming out the screen to the minimum limit, vice versa. Another operation was mixed in the above operation; moved the map to utmost of four directions (up, down, left and right) after zoomed the screen every time. In the

process of testing, an observation was based on conformity between current positions of additives (included red mark, thumbtacks, and arrows) and altered map.

As results of the above executions in Figure 20, it is unequivocal that every item chords perfectly with the original goals. Regarding to the data of locating ,the average deviation of location of five testing points is equal to 4.4 meters, and a rational conjecture is that situation of physical environment fluctuate the acceptance of GPS with a positive correlation. Hence, the nuance can be abrogated in a level of software.

testing point	locating	augmented reality	zooming	moving
1	about 2 meters	success	success	success
2	about 9 meters	success	success	success
3	about 5 meters	success	success	success
4	about 4 meters	success	success	success
5	about 2 meters	success	success	success

Fig 20. Results of five testing points in location, augmented reality, zooming and moving.

The detection in navigation was relatively complicated; investigator was demanded to severally input the logograms of every building to launch related navigation events in the five testing points, and then walked to the other four points for observing whether the real-time switchover among entrances (thumbtacks) of the target building conforms to an expectation of current position (red mark). Tabulation 21 lists verbatim evolvement process of each possible event of each mapping.

	FB	SB	CB	EB	BA	BB	PB	EE
1 → 2	FB3	SA→SAPB	LB3	EB2→EB1	BAPB→BA	BB2→BB1	SAPB→BAPB	SDEE→EBEE
1 → 3	FB3→FB2→FB1	SA→SAPB	LB3	EB2	BAPB	BB2	SAPB	SDEE
1 → 4	FB3→FB2→FB1	SA→SB→SC→SD	LB3→LB2→LB1	EB2→EBEE	BAPB	BB2	SAPB	SDEE
1 → 5	FB3→FB2→FB1	SA→SB→SC→SD→SDEE	LB3→LB2→LB1	EB2→EBEE→EB1	BAPB→BA	BB2→BB1	SAPB→BAPB	SDEE→EBEE
2 → 1	FB3	SAPB→SA	LB3	EB1→EB2	BA→BAPB	BB1→BB2	BAPB→SAPB	EBEE→SDEE
2 → 3	FB3→FB2→FB1	SAPB	LB3	EB1→EB2	BAPB→BA	BB1→BB2	BAPB→SAPB	EBEE→SDEE
2 → 4	FB3→FB2→FB1	SAPB→SA→SB→SC→SD	LB3→LB2→LB1	EB1→EB2→EBEE	BA→BAPB	BB1→BB2	SAPB→BAPB	EBEE→SDEE
2 → 5	FB3→FB2→FB1	SAPB→SDEE	LB3→LB2→LB1	EB1	BA	BB1	BAPB	EBEE
3 → 1	FB1→FB2→FB3	SAPB→SA	LB3	EB2	BAPB	BB2	SAPB	SDEE
3 → 2	FB1→FB2→FB3	SAPB	LB3	EB2→EB1	BAPB→BA	BB2→BB1	SAPB→BAPB	SDEE→EBEE
3 → 4	FB1	SAPB→SA→SB→SC→SD	LB3→LB2→LB1	EB2→EBEE	BAPB	BB2	SAPB	SDEE
3 → 5	FB1	SAPB→SDEE	LB3→LB2→LB1	EB2→EBEE→EB1	BAPB→BA	BB2→BB1	SAPB→BAPB	SDEE→EBEE
4 → 1	FB1→FB2→FB3	SD→SC→SB→SA	LB1→LB2→LB3	EBEE→EB2	BAPB	BB2	SAPB	SDEE
4 → 2	FB1→FB2→FB3	SD→SC→SB→SA→SAPB	LB1→LB2→LB3	EBEE→EB2→EB1	BAPB→BA	BB2→BB1	SAPB→BAPB	SDEE→EBEE
4 → 3	FB1	SD→SC→SB→SA→SAPB	LB1→LB2→LB3	EBEE→EB2	BAPB	BB2	SAPB	SDEE
4 → 5	FB1	SD→SDEE	LB1	EB2→EB1	BAPB→BA	BB2→BB1	SAPB→BAPB	SDEE→EBEE
5 → 1	FB1→FB2→FB3	SDEE→SD→SC→SB→SA	LB1→LB2→LB3	EB1→EBEE→EB2	BA→BAPB	BB1→BB2	BAPB→SAPB	EBEE→SDEE
5 → 2	FB1→FB2→FB3	SDEE→SAPB	LB1→LB2→LB3	EB1	BA	BB1	BAPB	EBEE
5 → 3	FB1	SDEE→SAPB	LB1→LB2→LB3	EB1→EBEE→EB2	BA→BAPB	BB1→BB2	BAPB→SAPB	EBEE→SDEE
5 → 4	FB1	SDEE→SD	LB1	EB1→EB2	BA→BAPB	BB1→BB2	BAPB→SAPB	EBEE→SDEE

Fig 21. Test results of mapping about navigation

6.1.2 White box testing

Even though the outputs of every function is correct in Black box testing and Integrating testing, a further testing still should be exerted to warrant exhaustively rigor of every involved arithmetic. After gearing by white box testing, the errors of rithmetic() in the class myTran, setSearch() and matrixCheck() in the class DrawView were eliminated.

6.1.3 System testing

Besides the above-mentioned testing, a consideration should be superimposed on the individual functions for verifying whether the constricted entirety is available. XJTLU Maps was installed in MEIZU MX2(cell phone) and Samsung GT-N8000(tablet device) to bilaterally detect different presentations of each function, and the

consequence is negligible.

6.2. Performance analysis

As a substantial product, XJTLU Maps possesses some concomitant properties which are utilized to reckon its performance by customers. In this chapter, an unprejudiced evaluation aims to deliver the concrete strengths and weaknesses to target customers, and engender relevant introspections of designer for further ameliorations. Involved factors can be modularized into explicit criteria: functionality, reliability, usability, efficiency, maintainability, and transferability. Among the criteria, functionality should serve as an important part to be elucidated for incarnating intuitively the status of XJTLU Maps in the market environment.

6.2.1 Functionality

As analyzed in specification and design, the motivation of this application is to solicit a targeted user population by creating more featured functions than other navigation software. In the assessment of functionality, all realizations of XJTLU Maps are pondered to be experimental objects to compare with corresponding modules of Baidu Maps which is nominated as a control group, and the involved slants embrace locating, navigation, and augmented reality. During experiment, equivalent user cases are simultaneously conducted in Baidu Maps and XJTLU Maps; at the same place and time, investigator invokes same function to test Baidu Maps and XJTLU Maps by two running devices.

As presented in Figure 22, two applications both sustain unassailable accuracy in the function of locating, but the outcomes XJTLU Maps manifests are more vivid than Baidu Maps at some level. Concretely, a majority of small-scale facilities (e.g. path, green belt, and tennis count) are described by pigmenting, and buildings are outfitted with 3D scene rendering for users' attention. In contrast, Baidu Maps uses abstract geometric figures to outline perfunctorily the buildings, even omits reference of

surrounding. According to the difference between two sides of Figure, users of XJTLU Maps will receive the information of output more rapidly and adequately than users of Baidu Maps. This is an advantage in Baidu Maps that the current orientation of users is denoted, but it is subordinate in a small-scale application.

Fig 22. Compare with Baidu Maps in locating

In terms of augmented reality (in Figure 23), Baidu Maps does not sponsor an interaction between a virtual world screen display and a factual world users situate. Compared with Baidu Maps, it is optimized in XJTLU Maps that users can spontaneously tackle different hierarchies of information by clicking thumbtacks.

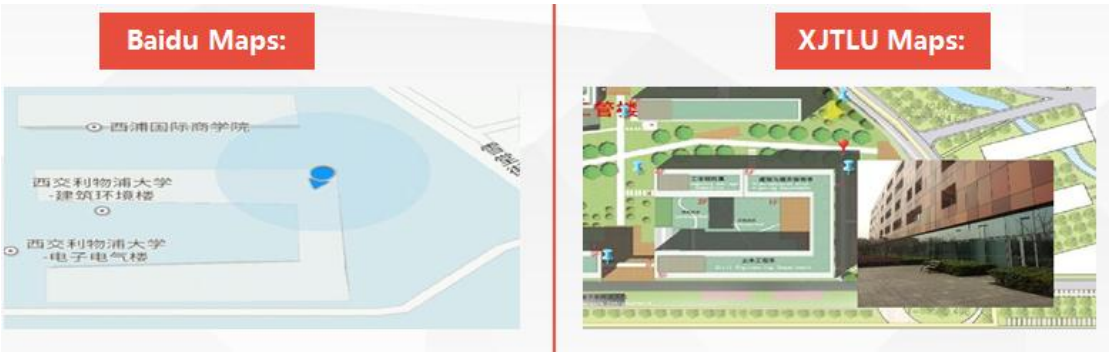


Fig 22. Compare with Baidu Maps in augmented reality.

Owing to a deficiency of pivots (included thumbtacks and arrows) in Baidu Maps, a topology of scanty data is incompetent to implement optimal route planning through lightweight computing. In XJTLU Maps, limitation of geography scope expiates

precisely a possibility that each intersections and entrances can be explored to be an optional element for optimal route. For example in Figure, a navigation event is evoked to probe an optimal route from Built Environment Building to Science Building, and the output of XJTLU Maps is more closely aligned with alleged optimal route than Baidu Maps. Two conspicuous differences are: (1) Baidu Maps discerns merely main streets, but all underlying paths are digitized to store in XJTLU Maps. (2) Only one mark is able to act as the terminus for all navigations of Baidu Maps aims to reach Science Building. In Baidu Maps, there are six thumbtacks around Science Building, which is salutary to winkle the optimal route through a set of comparisons. Moreover, the tedious demonstration of route in Baidu Maps vitiates user experience to some extent; the sinuous route advertises a coerciveness of correspondence and conceals background information. On the contrary, XJTLU Maps develops a mechanism to specialize the crux. Figure 23 displayed the aforementioned details in the degree of vision.

Fig 23. Compare with Baidu Maps in navigation

6.2.2 Reliability

Reliability is an average degree of performance the software maintains in various situations. For this aspect, XJTLU Maps is competent: (1) reflected in that this application constructs some safeguards to prevent users' mistakes during implementation; Critical values are configured to reserve an option of retreating to users. (2) reflected in that this application can continue to carry out when failures

occur; when users are indoor without matched GPS data, the method displayOldLocation() is invoked to supply last known GPS information to ensure normal realization of other operations.

6.2.3 Usability

User experience is practically weighed throughout the development process. For instances, an effect of flashing facilitates that an optimal route on screen is salient in visual sense, and it is user-friendly that user can resize and move the map to focus details. In addition, the "User instructions" in this report conduces to users' comprehension about how to trigger functions, input data, and recognize output.

6.2.4 Efficiency

On prescriptive situations, efficiency is a usage of device resources when certain functions are executed, and specific contents contain utilization of internal storage and external storage, channel capacity, and handling time. In XJTLU Maps, for economizing superabundant calculating costs, it is a tradeoff to sacrifice partial user experience that a postponement of presentation exists in the implementation of resizing.

6.2.5 Maintainability

In an executable application, maintainability is expressed as a difficulty of modifying some apropos components of a software system when users demand, environment is altered, or errors occur. In order to maintain the data of all thumbtack and road signs on the map, a lightweight SQLite database is embedded to record the information. Clients are portable to supplement and amend is a chief reason why not substitute the method of database by accessing directly all data in java programming.

6.2.6 Transferability

Due to a limitation of development environment, it is inductile that XJTLU Maps can just be installed in some devices which are based on Android platform.

6.3. Conclusion

To sum up, this project has been primarily completed to publish an initial version based on a technological process of software engineering, and a chain of testing guarantee the robustness of XJTLU Maps. Competed with Baidu Maps, the peculiarities of XJTLU Maps stabilize own target population, which affirms the meaning of development of XJTLU Maps. Except the realizations, XJTLU Map was committed to balance the attributes of software.

7. User instructions

Some segmental contents of the chapter "Realization" will be reiterated in here, and the obligatory reason is that this section is intended to enumerate entire instructions which can be applied to consult by users who want to savvy the usages of XJTLU Maps but do not dabble any knowledge of Android System. Except the recapitulations, aberrant user cases will also be prompted as an illustration. There is a repertoire with:

- Appellation of every building is watermarked by Red Chinese characters in the unadorned picture of XJTLU campus.

- Red mark is movable, and represents the current position you are in XJTLU campus.

- Blue thumbtacks are immovable, and represent the entrances of all buildings of XTTLU.

- Blue arrows are immovable, and represent the indications of orientation in an event of navigation.

- Each thumbtack has an opportunity to serve as a destination of a navigation route based on various combinations of your current position and your search value; vice versa, a destination of a navigation route must be a thumbtack instead of an arrow.

- When you click a thumbtack on the screen, the right side of this thumbtack displays a relevant photo that describes the actual scenery of the entrance of the building.

- You are merely allowed to view an image by clicking a thumbtack at a time; a concurrence of operations is prohibitive.

- When you type a character string in the input field and then click the button "GO TO SEARCH", the function of navigation will be sparked off.

- In the state of idleness for the input field, a text "PLEASE ENTER THE DESTINATION YOU WANT TO GO" is hinted on the background. This text will be superseded by a cursor if you touch ant space of the input field, which signifies you can process to input your data for searching.

- It is invalid that clicking the button if the input field is null.

- For emerging the optimal route XJTLU Maps estimated, a thumbtack and a series of arrows are highlighted by an effect of flashing.

- During the time of that you are tracing the route, XJTLU Maps is updating the state of these arrows which includes direction and whether appearing.

- For a given navigation event, a thumbtack as the destination of the route is not

going to altered in the process of application, unless you input a new character string to override.

- The character string you input is just truncated into first two characters, and whether upper case or lower case. There are all available prefixes:
  "FB" means Foundation Building;
  "SB" means Science Building;
  "CB" means Central Building;
  "EE" means Engineering Building;
  "BA" means Northern Part of Business, Economics and Management Building;
  "BB" means Southern Part of Business, Economics and Management Building;
  "PB" means Public Building;
  "EB" means Built Environment Building;

- If your input does not conform to the regulations of the above item, a pop-up toast widget (shown in Figure 21) will fade in as a reminder, and the time of duration is three seconds.

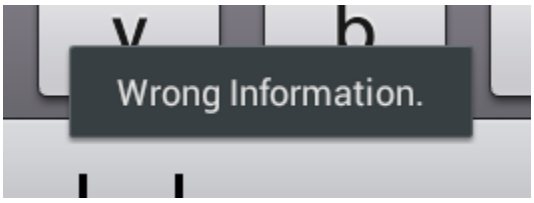


Fig 21. A toast to remind wrong input.

- Pinching by two fingers can resize the map.

- Sliding by one finger can move the map.

- A limitative situation is that the operation of sliding is approved if the operation of pinching has been executed.

- When your position outstrips the scope of XJTLU campus, a reflection on the screen is that red mark will disappear. However, the information of current position is still obtained, which implies the function of navigation is enabled.

- Regarding to the implementation of resizing, the screen will not automatically focus the region you pinched. Therefore, a substitution is that you need to manually slide to a position of the screen you aim to view.

8. Learning points

As things stand, the anticipative goals have been fulfilled generally during a gradual achievement of project schedule. In the experience of Final Year Project, some accompanying learning points have been cultivated as acquisitions, and this chapter will narrate the contents by a subjective perspective.

From an aspect of knowledge, I have been proficient in the development of Android platform, for instances: the arrangement of widgets, the mechanism of matrix object about transfiguration of image, etc. As the main programming language, my mastery of JAVA skills has been escalated to a more excellent degree than a year ago. In order to build a SQLite database to maintain the apropos functions, basic principles and syntaxes of database has been dabbled as well. Regarding to an involvement that the theories of software engineering have applied in XJTLU Maps, I have understood how to standardize every detail of development, for instances: adapter pattern was utilized to adhere a new application interface, debugging some errors I encountered, even going so far as to enact a academic procedure in entire development.

Meanwhile, final accomplishment of this project has been also braced by manipulative ability. Specifically, I have twigged every step in digitization of resource: (1) How to conduct a field trip to collect data. (2) How to sift aberrant cases. (3) How to analyze multiple connections among target data. (4) How to translate the revised data to suitable information machines can receive; invent my own logical frameworks

to correspond the features of XJTLU Maps.

- Furthermore, there is a spate of enlightenments which have nurtured me to penetrate into the essence of software development:

- As a designer, I have learnt to place myself in users' position to wonder what they practically want to obtain from this application.

- This project have explored and searched by a motivation that computer science serves as implementation tool to tackle a practical problem, so every realization I dedicated should be based on truths.

- For a project, the integration needs to be unraveled into individual functions to realize rather than an admixture of semi-finished goods.

- Testing is a process to unremittingly detect errors and unremittingly ameliorate during a project.

- Robust software should maintain expansible space to some extent.

9. Professional issues

I have implemented the Final Year Project in accordance with Code of Practice and Code of Conduct issued by British Computer Society. I warrant that all contents in this project have been realized within the scope of my competence. An act of altruism is praised highly in this project; I permit that future searches can expand based on my products. As far as I'm concerned, I will enrich XJTLU Maps with more technological realizations by burnishing my capacities.

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11. Appendix

SQLite Database

ID	LONGITUDE	LATITUDE	REVEAL	LINK	DESCRIBE
1	120.7361486	31.27397645	Y	2,23	1
2	120.7347866	31.27392631	Y	1,3	2
3	120.7347808	31.27448839	Y	2,4,7,15	3
4	120.73339	31.27449631	Y	3,5	4
5	120.7329414	31.27579744	Y	6,11	5
6	120.7338063	31.27581019	Y	5,7	6
7	120.7347518	31.27581472	Y	3,6,8,14	7
8	120.73492	31.27664275	Y	7,9,13	8
9	120.7348744	31.2773168	Y	8,10,12	9
10	120.7338013	31.27738651	Y	9,11	10

11	120.7323321	31.27736426	Y	5,10	11
12	120.7360873	31.27736854	Y	9,13,20	12
13	120.736112	31.27661348	Y	8,12,14,19	13
14	120.7360955	31.27578523	Y	7,13,15,17	14
15	120.7361629	31.27469791	Y	1,3,14,16	15
16	120.7371454	31.27484693	Y	15,17,21,23	16
17	120.7372153	31.27585755	Y	14,16,18	17
18	120.737872	31.275884	Y	17,19,21	18
19	120.7374073	31.2765127	Y	13,18,20	19
20	120.738023	31.27737316	Y	12,19	20
21	120.7387826	31.27496598	Y	1,18,22	21
22	120.739256	31.2740757	Y	21	22
23	120.7373067	31.27397335	Y	1,16,22	23
24	120.7384619	31.27472657	N	16,21,22	EB1
25	120.7384367	31.27514485	N	16,18,22	BB1
26	120.7380598	31.27555576	N	18,21	BA
27	120.7371343	31.27560394	N	16,17	BAPB
28	120.7373068	31.27504639	N	16,17,21	BB2
29	120.7373769	31.27472419	N	16,23	EB2
30	120.7372229	31.27421089	N	16,23	EBEE
31	120.7361264	31.27424258	N	1,3,15	SDEE
32	120.7360831	31.27556289	N	14,15	SAPB
33	120.7349898	31.27556786	N	3,7	SA
34	120.7350274	31.27514893	N	3,7	SB
35	120.7349965	31.27464488	N	3,7	SC
36	120.7350587	31.27420174	N	2,3	SD
37	120.7343838	31.27505983	N	3,7	LB1
38	120.7338125	31.27465776	N	3,4	LB2
39	120.733818	31.27543948	N	6	LB3
40	120.7337928	31.27631013	N	6,8	FB1
41	120.7344929	31.27665487	N	8	FB2
42	120.7337598	31.27690212	N	10	FB3