The Demodulating and Encoding Heritage (DEH) Platform for Mobile Digital Culture Heritage (M-DCH)

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Abstract

This work designed and developed an innovative Mobile Digital Culture Heritage (M-DCH) platform called Demodulating and Encoding Heritage (DEH) to allow users to have the on-site exploring of the culture heritage using handheld devices and wireless mobile networks. Since most of the current M-DCH platforms (i) view a heritage object as a point and (ii) do not have the group-like authoring scenario, main innovations of the DEH platform are twofold. (1) DEH interprets M-DCH's contents from the viewpoint of Point of Interest (POI), Line of Interest (LOI), Area of Interest (AOI), and Story/Site of Interest (SOI). The authors' roles of POIs/LOIs/AOIs/SOIs can be classified as player (regular users), expert and narrator. The work defines the logic rules of composing some POIs (POIs, LOIs and/or AOIs) into a LOI/AOI (SOI) according to (i) the author's role and (ii) the status, which can be (i) public or private and (ii) successfully verified, unsuccessfully verified or un-verified of the corresponding LOI/AOI (SOI). (2) DEH defines a new grouping function that allows the group creator to have the privilege of modifying contents created by group members. Details of the functional specification, system design and usage examples of DEH's APPs and web are presented.

Keywords: Mobile Digital Cultural Heritage (M-DCH), Mobile digital content, Metadata, Mobile Social Network (MSN), Location-based Service (LBS)

1 Introduction

Digital Cultural Heritage (DCH) tries to utilize Information and Communication Technology (ICT) to preserve cultural heritage and then to enable some applications and services [1]. For example, applying text, image, video, audio to enhance the presentation of cultural heritage [2-3], adopting the information retrieval technique to search digital cultural heritage contents more conveniently and precisely [4], using the Location Based Service (LBS) technique to really tour cultural heritage sites or virtually tour cultural heritage sites using e-map [5-6]. With the advanced and popularly used wireless mobile computing devices and communication techniques, it is the era to have Mobile DCH (M-DCH), for which its key characteristic is for walking into the cultural heritage sites to have the on-site exploring through the help of handheld devices and wireless mobile network. That is, M-DCH can extend DCH from E-Heritage to Ubiquitous Heritage (U-Heritage).

In addition to the existed work, according to our observation, three main concerns that an M-DCH platform needs to consider are (1) digitalized contents for interpreting and preserving cultural heritage in various viewpoints, (2) technical functions for manipulating digitalized cultural heritage's contents and (3) applications and services of utilizing digitalized cultural heritage's contents based on the technical functions. This work designed and developed an M-DCH platform called Demodulating and Encoding Heritage (DEH) to tackle issues of the aforementioned three concerns. For the digitalized content concern, M-DCH has different characteristics such that it can be interpreted from the viewpoint of point, line, area and story/site. Thus, in addition to the regular Point of Interest (POI), which is the basic unit of M-DCH and can contain text plus image/pictures, video or audio, three more content sorts that the proposed DEH platform defines are (i) Line of Interest (LOI), (ii) Area of Interest (AOI) and (iii) Story/Site of Interest (SOI). A LOI is a sequence of POIs in which a visiting sequence of the composed POIs is enforced to have the temporal or spatial view and interpretation of the contained POIs. An AOI is a set of POIs in which the composed POIs are related, but the visiting sequence of them can be random. An SOI can contain many units, in which each unit can be a POI, a LOI or an AOI, to describe a complete story or a site of cultural heritage. For readers convenience, Table 1 depicts the meaning of abbreviations used in this paper.

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Table 1. The abbreviations used in this paper

Abbreviation	Denotation
DCH	Digital Cultural Heritage
M-DCH	Mobile Digital Culture Heritage
DEH	Demodulating and Encoding Heritage
POI	Point of Interest
LOI	Line of Interest
AOI	Area of Interest
SOI	Story/site of Interest
DCMI	Dublin Core Metadata Initiative

A metadata set is required to formally describe POI, LOI, AOI and SOI respectively. For POI, which is the basic sort of content in DEH, DEH utilizes the simple Dublin Core Metadata element set [7-8], which defines fifteen properties to describe digital contents, as the base and adds additional attributes to model a POI in M-DCH. For example, the location attribute, which contains longitude and latitude, of the POI is added for describing a DEH's POI. For LOI, AOI and SOI, DEH defines the corresponding metadata sets based on the requirement of their functional scenarios respectively.

For the technical functions, in addition to the regular functions of authoring and exploring, two new technical functions that DEH defines and provides are (i) the content verification and (ii) the grouping function based on Mobile Social Network (MSN). The DEH platform allows users to set their created content as public or private. For the public content, DEH uses the verification mechanism to check whether it contains improper content, e.g., text/pictures/video/ audio that contain sex, violence or some unsuitable materials, to be public or not; for the private content, it can be stored without verification. For the aspect of the grouping function based on MSN, a group in DEH is composed of a group creator/leader and some members. In addition to the regular group functions i.e., sharing the content to group members, which belongs to the "read" action, defined in currently available social network, e.g., FB, LINE and WeChat, DEH's grouping function allows the group creator/leader to have the privilege of modifying contents created by group members, which belongs to the "write" action. This function is especially needed for content creation and sharing that is instructed in the instructor-student way.

For the application and service aspect, DEH can be multi-disciplinary. DEH can be used for (i) touring cultural heritage, (ii) education of cultural heritage in schools, (iii) preserving cultural heritage, (iv) narrators of cultural heritage as the wireless mobile computer-assisted exploring system during their on-site explaining cultural heritage for their customers. Thus, the users of DEH are classified as regular users (player), cultural heritage experts (expert), and cultural heritage narrators (narrator).

From the system viewpoint, the DEH platform contains (1) web-based and APP-based authoring sub-systems and exploring sub-systems, (2) MSN-grouping and verification functions and (3) web and mobile APIs for DEH's web and APP sub-systems respectively. The DEH platform contains (i) a website (http://deh.csie.ncku.edu.tw), (ii) an APP called DEH Make that can be used for on-site authoring POIs, which can contain image/audio/video plus text, and (iii) an APP called DEH Mini that allows users to download DEH's contents to have on-site or virtual touring. DEH Mini has two options: download neighboring POIs/LOIs/AOIs/SOIs that were made by all users or just download neighboring POIs/LOIs/ AOIs/SOIs that were made by the user herself/himself. Since the status of a POI/LOI/AOI/SOI can be (i) public or private and (ii) successfully verified, unsuccessfully verified or un-verified, the work defines the logic rules of composing some POIs (POIs, LOIs and/or AOIs) into a LOI/AOI (SOI) according to the author's role of the corresponding LOI/AOI (SOI). The presentation principle of a LOI/AOI (SOI) is also implemented accordingly.

The rest of this paper is organized as follows. Section II introduces related work. Section III presents the platform architecture and main issues of the system development. Section IV presents the authoring and the exploring systems. Section V presents MSN-grouping and verification function. Section VI illustrates the usage and example of the DEH platform. Finally, Section VII has some discussions and conclusion remarks.

2 Related Work

This Section introduces related work for the DEH platform.

2.1 Dublin Core

The Dublin Core Metadata Initiative (DCMI) [8] aims to provide an open metadata standard for online resources, including image, audio and video. The simple Dublin Core Metadata element set, which includes 15 elements depicted in Table 2, concentrates on preserving the digital contents of refinement and essential.

2.2 Digital Cultural Heritage (DCH)

DCH is a service that preserves the cultural and natural heritage using digital media, which can be created, shared, modified and preserved on digital devices and systems, i.e., on the web system [9]. In [10], the authors proposed a multi-disciplinary framework considering the digital collections, information searching of the members in a community, the metadata of cultural heritage and the application of the data. The proposed method is called Digital Library North (DLN), which is for (1) environmental scanning, (2) community engagement and. (3) community-driven digital libraries. In [3], the authors proposed the

Table 2. Simple dublin core metadata elements and definitions

Term	Definition
Contributor	An entity that is responsible for making contributions to the resource.
Coverage	The spatial or temporal topic of the resource, the spatial applicability of the resource, or the jurisdiction under which the resource is relevant.
Creator	An entity that is primarily responsible for making the resource.
Date	Data's created Date.
Description	An account of the resource.
Format	The file format, physical medium, or dimensions of the resource.
Identifier	An unambiguous reference to the resource within a given context.
Language	The language of the resource. (Chinese/ English/Japanese/…)
Publisher	An entity that is responsible for making the resource available.
Relation	A related resource.
Rights	Information about rights held in and over the resource.
Source	A related resource from which the described resource is derived.
Subject	The topic of the resource.
Title	A name given to the resource.
Type	The type of the resource.

multimedia interactive and service system for intangible cultural heritage, which include video, audio, text, and 3D scenes. This DCH platform not only protects the cultural heritage but also attracts more people to know their countries' or regions' culture. In [6], the authors proposed a DCH platform called RouteYou, which focuses on the automatic collection and multimodal enrichment of POIs used in the routing algorithm. The automatic procedure can estimate the POI's quality with the attraction-accessibility score to measure its spatial importance.

2.3 Location Based Service (LBS)

LBS provides users the location services using GPS-enabled mobile devices to collect their current locations to design the corresponding applications. By collecting location data, the services can offer the information around the users. In [11], the authors proposed a LBS platform that can collect nearby information and manage the collected information on the website. The proposed application supports the location positioning and searching, vehicle monitoring and supervising, schedule management, map tagging, etc. In [12], the authors proposed the Group Nearest Neighbor (GNN) mechanism to find POIs, which are in the nearest distance of users' current group. The proposed method uses a light weight and distributed multi-party private protocol to compute the nearest POIs and prevent the unnecessary data. The Location Based Social Network (LBSN) is an LBS that combines with the social network to recommend contents for groups and also recommend groups for nearby users [13].

3 Architecture

The architecture of the DEH platform aims to support the services for both website and mobile devices. Referring to Figure 1, four main functions that the Django-based Web API on the server side provides are Authoring sub-system, Exploring sub-system, Grouping function and Verification function for the website; the Node.js-based Mobile API on the server side supports the aforementioned functions, excluding the Verification function, for mobile devices. Both APIs utilize the Google Map API.

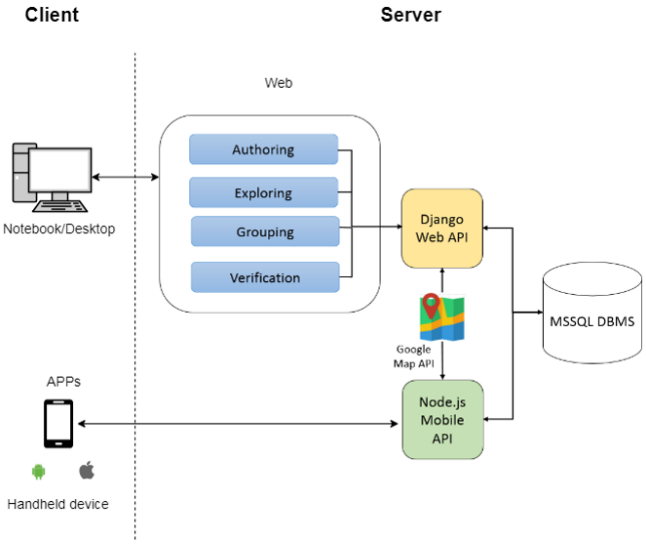

Figure 1. System architecture of the DEH platform

Three roles that users of the DEH platform can be are *player*, *docent*, and *expert*. The role of *player* is for the regular users that choose the "player" option. A user with the *player* role can (i) create her/his account/password in the DEH platform by herself /himself and then create contents and (ii) explore others' contents freely. The role of *docent* is for users who are narrators of explaining cultural heritage for others. A user with the *docent* role also can do the same actions as the player user does. The main difference is that a user with the *docent* role can fill her/his personal information, e.g., the price she/he asks for and the languages that she/he can use, in her/his registered user profile. The personal information can be shown when other users view and/or hear the corresponding contents made by the narrator. By showing narrator X's personal information, other users who are interested in X's contents can contact with X to have X's on-site explanation. The role of *expert* is for users that are experts of cultural heritage. To control the quality, the accounts for users with the

expert role are on-demand. That is, the administrator of the DEH platform will check the qualification of the requested users that want to have the *expert* role and then issue the accounts accordingly. The privilege of an expert user is the same as that of a player user.

For system management, two roles of the system managers are (i) administrator and (ii) verifier. An administrator has the highest authority over the DEH platform, e.g., the administrator can add, modify, delete and verify all contents. A verifier in the DEH platform has the privilege to verify the contents.

3.1 Fundamentals of Authoring DEH Contents

The authoring sub-system provides services for registed users to (i) create contents and share their contents with others who are browsing the DEH platform or (ii) privately own their contents.

In addition to define POI's metadata elements, which are based on the Dubbin Core Metadata element set [7-8], LOI, AOI and SOI also need a set of metadata elements respectively to record the corresponding contents. This work defined a set of metadata elements for LOI, AOI and SOI respectively depending on the characteristics and the corresponding technical system's functional requirements of LOI, AOI, and SOI respectively.

Depending on the authorship, the DEH platform can allow a user with the *player*, *docent*, or *expert* authorship to create POIs, LOIs, AOIs and/or SOIs. For each sort of the digital contents, i.e., POI, LOI, AOI or SOI, the corresponding author can mark it as public or private, for which the former one needs to be verified by the DEH verifier. The corresponding POI, LOI, AOI or SOI that is marked as public can be viewed by all users if the verification is passed.

3.2 Fundamentals of the DEH Exploring Sub-System

The exploring sub-system aims to provide users the exploring mechanism on the website or APPs, for which the former one, i.e., exploring through the web, emphasizes on the virtually exploring cultural heritage and the later one, i.e., exploring using APPs, emphasizes on the on-site exploring cultural heritage. Users of the DEH platform can choose which language, i.e., Chinese, English or Japanese currently, they want to use. The DEH platform provides some filtering criteria such that users can get the contents that they want to search currently. Additionally, the DEH platform records users' exploring experience, e.g., the downloading POIs in a user's navigating path on a specific day, for users' and system's reference.

In the DEH platform, public and verified are the primary filtering requirements in the exploring mechanism. The exploring sub-system only filters out the public and successfully verified contents for users for the reason of protecting other users' privacy and controlling the appropriate contents on the platform. Moreover, the necessary filtering requirements are (i) the role (*player*, *docent*, and *expert*) of the content's author (ii) the language i.e., Chinese, English, or Japanese, to be used and (iii) the geographic area of contents. The secondary filtering requirements are the additional conditions, which are optional, based on POI's metadata i.e., subject, type, and format, which are chosen by users. The third filtering requirements are also optional and are based on the media type of POI, i.e., image, audio or video. The filtering requirements of LOI, AOI and SOI are the same as the primary and necessary filtering requirements of POI. In summary, users can have the following options to search contents that are stored in the DEH platform: (1) filtering contents based on the system restriction i.e., public and successfully verified, author's role i.e., *player*, *docent*, or *expert*, language and the geographic area; (2) filtering contents based on the POI metadata, i.e., Subject, Type and Format; (3) multimedia's type of POI, i.e., picture/image + text, video + text, or audio + text. On the DEH APP, filtering contents is based on the geographic position, i.e., selecting the neighboring k POIs/LOIs/AOIs/SOIs in the n kilometers of the user's current location or the location that the user pinpoints in the Google Map on the APP of DEH Mini; in contrast, it uses the administrative division, i.e., city/township and country, on the web system. In addition to set the filtering options on the DEH platform, the exploring sub-system also allows users to type in some keywords to search interested POIs/LOIs/AOIs/SOIs on the web.

3.3 The MSN-based Grouping Function

The grouping function provided in the DEH platform is similar to that in Line and WeChat. Each user of the DEH platform can create and join one or more groups on the DEH platform. Two main concerns of the DEH's grouping function are as follows: Different from Line and WeChat, each group creator/leader has the privilege to modify the contents that each member added into the group. Thus, group creator/leader and members can work together for better contents. The other main concern of providing the grouping function is that a group of users, who are interested in viewing each other's contents, do not need to view those POIs/LOIs/AOIs/SOIs made by non-group members in the exploring sub-system.

A user who creates a group is called group leader. The group leader can send invitation to the users who are not in the group; a user who joins a group is called group member. A user can actively send a join request to the group leader to join the corresponding group. Nevertheless, invitation to join and request to join can be accepted or declined by the group leader or the corresponding user depending on her/his willingness.

The group leader is allowed to kick out an existed member. When an existed member of a group is kicked

out by the group leader, his/her contents can still be remained in the group. It is because of the consideration of content ownership: the leader may have edited the content and thus the content still belong to the group.

A group can be attributed as public or private; and thus the creation of a group also needs to be verified. When a group **X** is attributed as public, all DEH users can view those contents that belong to group **X** by searching the keyword "**X**". When a group is attributed as private, only group members can view group's contents. When a piece of content, e.g., a POI, a LOI, a AOI or a SOI, in the group is private or verified unsuccessfully, only the group leader and the content's author can view and manage the corresponding content.

3.4 The Verification Function

The verification function is designed for verifying the authored contents and groups. With the growing number of contents in the database, the uploaded contents need to be controlled to maintain the quality and credibility of DEH. The verification function in the DEH platform is to limit those contents that are excessive spread, error information or over-repeated. DEH verifiers, whose accounts have the privilege to identify and verify the newly created POIs, LOIs, AOIs, SOIs and groups, are assigned to some professional experts and/or workers of digital cultural heritage to examine contents without the complicated process. If there are inappropriate contents such as violence, pornography or the correlation between titles, address and media has no connection, the verifier can have the negative verification such that these contents are not in public and can only be viewed by the corresponding authors, i.e., it just likes the private contents.

4 Authoring and Exploring Sub-system

This Section presents the kernel system designs and functional specifications of the authoring and exploring sub-systems of the DEH platform.

4.1 The MetaData for POI/LOI/AOI/SOI

The authoring sub-system is responsible for authoring the contents of POIs/LOIs/AOIs/SOIs. The POI authoring consists of filling contents to the corresponding attributes, which are based on the simple Dublin Core Metadata element set. For the mobile system's functional need, DEH (1) modifies the role and meaning of each simple Dublin Core Metadata element and (2) creates some new attributes, which are depicted in Table 3, to suit for the DEH platform's need.

Table 3. The metadata elements for DEH's Point of Interest (POI)

Term	Definition
Contributor	The name of POI's content provider(s)
Coverage	The spatial coverage of the POI
Creator	Entities that are primarily responsible for making the referred resource.
Date	Created Date of the POI.
Description	A set of texts for explaining the POI.
Format	It denotes the format of the cultural heritage to which the POI belongs.
Identifier	The role type, i.e., player, docent or expert, of the author.
Language	The language used for the description of the POI, which can be Chinese, English or Japanese currently.
Publisher	The publisher of the reference resources
Relation	Reserved for future usage.
Rights	The user account of the DEH user who makes and/or uploads the POI.
Source	The reference resources from which the POI's content is derived.
Subject	It denotes the current status of the cultural heritage to which the POI belongs.
Title	The title of the POI
Type	It denotes the type of the cultural heritage to which the POI belongs.

Comparing with the original simple Dublin Core Metadata elements, the "Format" element is transformed to specify the sort of cultural heritage that is formally defined in Taiwan, which can be the Historical Site, Ruins, Human-made Landscape, Natural Landscape, Antique, Traditional Art, Folk Custom, plus additional two sorts, including (i) Food, Clothing, Housing, Transportation, Education, and Entertainment and (ii) others, for users' convenience. The "Subject" element is transformed to classify cultural heritage based on the current status, which can be Experimental, Activation & Reconstructed and Disappeared. The "Type" element distinguishes the cultural heritage based on the association, which can be People, Event, Human-made Landscape, Natural Landscape and Industry. Source, Creator and Publisher are the title, author(s) and publishing institute/company of the reference book(s), article(s), etc., respectively, of POI's content. Element Relation is not used currently and is reserved for the future use. The other elements can refer the definition depicted in Table 2 and thus they are not explained again.

For the concerns of (i) recording the geo information, i.e., the location of the POI, for virtual or on-site touring, (ii) indicating which period, e.g., which dynasty of the Chinese history, the cultural heritage of the POI was built and (iii) meeting the requirement of keyword's searching, some additional metadata elements are depicted and explained in Table 4.

Table 4. The additional metadata elements for DEH's Point of Interest (POI)

Term	Definition
Area	The administrative division of the location of the POI
Period	The period in which the cultural heritage of the POI was built.
Keyword	The keywords that can be used for searching the POI.
Latitude	The latitude of the geo location of the POI.
Longitude	The longitude of the geo location of the POI.
Address	The current address of the POI.

The authoring sub-system allows the user to upload multimedia files, which can be image, video or audio file(s) that the POI is associated with, and the voice guide file for recording a piece of oral explanation that is added by the POI's author. DEH allows a POI to have (i) up to five picture/image files, one video or one audio file and (ii) one voice guide file, which is optional depending on the POI author's convenience. The metadata elements for recording the multi-media (image, audio, or video) content part of a POI are depicted in Table 5.

Table 5. The metadata elements for describing the multimedia content part of a POI

Term	Definition
URL	The path that is directed to the stored location of the corresponding POI.
Type	The media file's format, i.e., .jpg, .png, .aac, .mp4, of the multimedia content of the corresponding POI.
Size	The size of the multimedia file.
Upload_time	The uploaded time of the associated multimedia content.
POI_id	The foreign key of the corresponding POI
Media	Type of the media file, which is 1 for image, 2 for audio, 4 for video and 8 for voice guide.

Table 6 depicts the metadata elements for LOI. The design principle for LOI's metadata elements is as follows. Elements "Title" and "Description" are used for the descriptive contents of the LOI. Since the contained POIs may belong to different administrative divisions, the DEH platform defines the Leader POI element, which is the first POI of the LOI, and then uses the Leader POI's administrative division to denote the LOI's administrative division. Accordingly, element "Area" records the corresponding administrative division of the LOI, which is the same as that of the Leader POI. Some quantitative numbers are needed for users' convenience and system's processing. Thus, elements "Transportation", "Time of Trip" and "Coverage" are used to record the suggested transportation way, the touring time length and the whole geo distance of the LOI respectively. Elements "Upload time" and "Owner" are used to (i) denote the uploading time and (ii) record the author(s) of the LOI respectively. These two elements are used for system processing.

Table 6. The metadata elements for DEH's Line of Interests (LOI)

Term	Definition
Contributor	The name of LOI content provider(s).
Title	The title of the LOI.
Description	A set of texts for explaining the LOI.
Area	The administrative division of the LOI.
Owner	The user account of the DEH user who creates and uploads the LOI.
Transportation	The suggested transportation way for physically experience the LOI.
Time of Trip	The touring time of the LOI.
Coverage	The whole geo length of the LOI.
Upload_Time	Created date of the LOI.
Leader POI	The first POI of the LOI.

Table 7 depicts the metadata elements for AOI. The design principle of AOI's metadata elements are as follows. Elements "No. of POIs" of the AOI is the amount of POIs contained in the AOI. Element "Representative POI" is set by the author of the AOI, which has the similar role of LOI's "Leader POI". That is, the representative POI's administrative division and area are used to denote the administrative division and area of the AOI respectively. The other elements are the same as that of the LOI and are not explained again over here.

Table 7. The metadata elements for DEH's Area of Interests (AOI)

Term	Definition
Contributor	The name of AOI content provider(s).
Title	The title of the corresponding AOI.
Description	A set of texts for explaining the AOI.
Area	The administrative division of the AOI.
Owner	The user account of the DEH user who creates and uploads the AOI.
Transportation	The suggested transportation way for physically experience the AOI.
No. of POIs	The number of POIs contained in the AOI.
Coverage	The geo distance range of the AOI.
Upload_Time	The created date of the AOI.
Representative POI	The representative POI of the AOI.

Table 8 depicts the metadata elements for SOI. Since these elements are the same as those for LOI and AOI, they are not explained over here.

Table 8. The metadata elements for DEH's Story of Interests (SOI)

Term	Definition
Contributor	The name of SOI content provider(s).
Title	The title of the SOI.
Description	A set of texts for explaining the SOI.
Area	The administrative division of the SOI.
Owner	The user account of the DEH user who creates and uploads the SOI.
No. of POIs/ LOIs/ AOIs	The number of POIs/LOIs/AOIs contained in the SOI.
Upload_Time	The created date of the SOI.
Representative POI	The representative POI of the corresponding SOI.

In the DEH platform, to have more flexibility of authoring LOIs, AOIs and SOIs, the author of (i) a LOI or an AOI is allowed to select POIs that were made either by herself/himself or by others as the composed POIs of the corresponding LOI or AOI, and (ii) an SOI is allowed to select POIs, LOIs and/or AOIs that were made either by herself/himself or by others as the composed POIs, LOIs and AOIs of the correspond SOI. The authoring principle of LOIs, AOIs and SOIs are different, depending on the author's role and the ownership of (i) the contained POIs in the correspond LOI/AOI and (ii) the contained POIs, LOIs and/or AOIs of the corresponding SOI. If the to be contained POIs (POIs/LOIs/AOIs) of the LOI/AOI (SOI) were authored by others or the corresponding author of the LOI/AOI (SOI) herself/himself, these POIs/LOIs/ AOIs/SOIs need to be attributed as public and have been successfully verified.

Since the DEH platform wants to be a promotion platform for narrators of cultural heritage and thus devises a mechanism to advertise a narrator's self-found and private POIs to show her/his uniqueness, a LOI/AOI (SOI) made by a narrator and is attributed as public is allowed to contain private POIs made by the corresponding narrator. Then, when a user clicks a private POI (POI/LOI/AOI) contained in a narrator-made LOI/AOI (SOI), only the title of the private POI (POI/LOI/AOI) is shown and the contained description and multimedia, i.e., pictures/image, video, or audio, will not be playout to attract users to contact with the corresponding narrators to have on-site exploring. This way can thus advertise/sell/promote narrators and thus, hopefully, increases the income of narrators of cultural heritage.

For the authoring principle of LOIs, AOIs and SOIs that are attributed as private, since it is attributed as private, i.e., they can only be viewed by the author herself/himself and not be viewed by other users, no restriction is enforced. Thus, if the to be contained POIs (POIs/LOIs/AOIs) of the LOI/AOI (SOI) were made by the author herself/himself, (i) they can be successfully verified, unverified, i.e., the DEH verifier still does not check and verify, or unsuccessfully verified when the attribute is public, and (ii) they can be attributed as private; if the to be contained POIs (POIs/LOIs/AOIs) of the LOI/AOI (SOI) were made by others, they still need to be attributed as public and have been successfully verified. The reason is that those

POIs/LOIs/AOIs made by others and are attributed as private or unsuccessfully verified cannot be viewed by others.

4.2 The Classification Processing of the Exploring Sub-System

The key issue of the exploring sub-system is the mechanism that allows users to filter out the contents the corresponding users want to view. Figure 2 depicts the classification way for filtering contents. The DEH platform allows users to specify Category, Role, Language, Subject, Format, Region, Type and Media, for which (i) Category can be POI, LOI, AOI or SOI, (ii) Region can be city, which is a city of Taiwan or Foreign country, which is any country on the world, and (iii) the others were already introduced previously and thus are not explained over here.

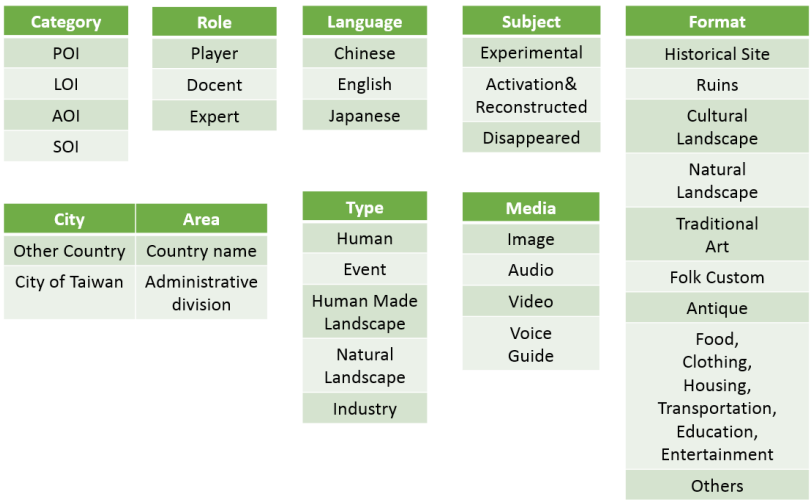

Figure 2. POIs' classification ways in the exploring sub-system

5 Advanced Functions

In this Section, the functional specifications of the grouping and verification functions are introduced in details.

5.1 The Grouping Function

The grouping function in the DEH platform is used to handle the contents of a group of users and the corresponding group users' management.

Table 9 depicts the metadata elements for the grouping function. Group name denotes the group and can be used to search when users want to join the group. Group information is the brief introduction of the group. Group creator/leader and Group members denote the two roles of users in the group. Join time is the time that a user joined the group. Group message records the message, which can be the invite-to-join, request-to-join or reject message between group creator/leader and users. Group contents contain the IDs of the POIs, LOIs, AOIs and SOIs that are selected as belonging to the group.

Table 9. The metadata elements for DEH's grouping function

Term	Definition
Group name	The name of the group.
Group information	The induction of the group.
Group creator/leader	The leader who creates the group.
Group member	Members of the group.
Join_time	The time that a user joined the group.
Group message	The messages between group creator/ leader and users.
Group contents	The POIs/LOIs/AOIs/SOIs that belong to the group.

A group creator/leader in the DEH platform has the following operational privilege:

Update group information. A group creator/leader is able to modify the content and information, including group name, group introduction, and accessing status, i.e., public or private.

Disband group. A group creator/leader has the privilege of disbanding the group. The membership of the corresponding members is disappeared and the contents that were attributed as belonging to the group are deleted after the group is disbanded. The existence of each piece of the content, i.e., POI, LOI, AOI or SOI, in the DEH database is decided by the individual author herself/himself after the group being disbanded.

Invite users to join the group. A group creator/leader can search users based on users' accounts and send invitation messages to the corresponding users. If the corresponding user agrees to join, then the member list is updated; otherwise, a refused message is sent to the group creator/leader.

Kick out member. A group creator/leader has the privilege of kicking out a specific member in the group for some reason. However, the corresponding contents made by the corresponding member still belong to the group, unless the corresponding member removes the belonging-ship.

Accept or decline the join requests of users. A user can request-to-join a group whose attribute is public and has been successfully verified by searching the group's name. If group creator/leader agrees the request-to-join message, then the user becomes a member of the group; otherwise, a reject message is sent to the corresponding user.

Manage contents in the group. A group creator/leader is able to create contents by herself/himself and modify members' contents, which were set as belonging to the group, directly. The modified contents are still owned by the original author, i.e., the corresponding member.

Inspect contents. A group creator/leader can inspect all of the contents, including private, unverified or unsuccessfully verified ones belonging to the group. If there are inappropriate contents, the group leader can remove them from the group.

A group member has the following operational privilege:

Join/ leave a group. A user can search and then request-to-join a group, whose attribute is public and has been successfully verified, that exists in the DEH platform. A user can reject the invitation from a group's creator/leader, if she/he feels that she/he is not suitable to join. A user also can actively leave the group.

Allocate contents. A group member is able to allocate some contents that were made by herself /himself into the group. Note that each piece of the content can only be allocated to one specific group. Once a piece of content is allocated into a group, it belongs to the group and the group creator/leader can modify or remove it from the group. The reason that a piece of content can only belong to a specific group is as follows: if it belongs to several groups, then these multiple modifications, which belong to the "write" action in the DEH database system, become conflicted from several group creators/leaders.

View contents. A group member can view other members' public and successfully verified contents and her/his own contents, including private, unverified and unsuccessfully verified ones, that are attributed as belonging to the group when the corresponding member is exploring the group's contents.

Those users, who are not the group members, are able to search these groups whose attributes are public and have been successfully verified. The allowed operations of a guest user in the group's management page are as follows:

View the information. A user who is not the group member can view the introduction of the group, whose attribute is public and has been successfully verified,

and can also view the member list of the group.
View contents. A user who is not the group member, can view the contents that belong to the group and are attributed as public and have been successfully verified.

5.2 The Verification Function

Each POI, LOI, AOI, SOI or group of the DEH platform is associated with attribute "verification", which indicates the verification status with the following value:

- 0: A newly created POI/LOI/AOI/SOI/Group that is waiting for verification.
- 1: Successfully verified POI/LOI/AOI/SOI/Group
- -1: Unsuccessfully verified POI/LOI/AOI/SOI/Group.

6 Usage and Examples

This Section introduces some usage examples of the DEH platform.

The DEH website provides the friendly layout using the Responsive Web Design (RWD) technique. RWD is a technique that renders web pages properly on any device according to the devices' screen size.

The authoring sub-system can upload a POI with media files, which are illustrated in Figure 3.

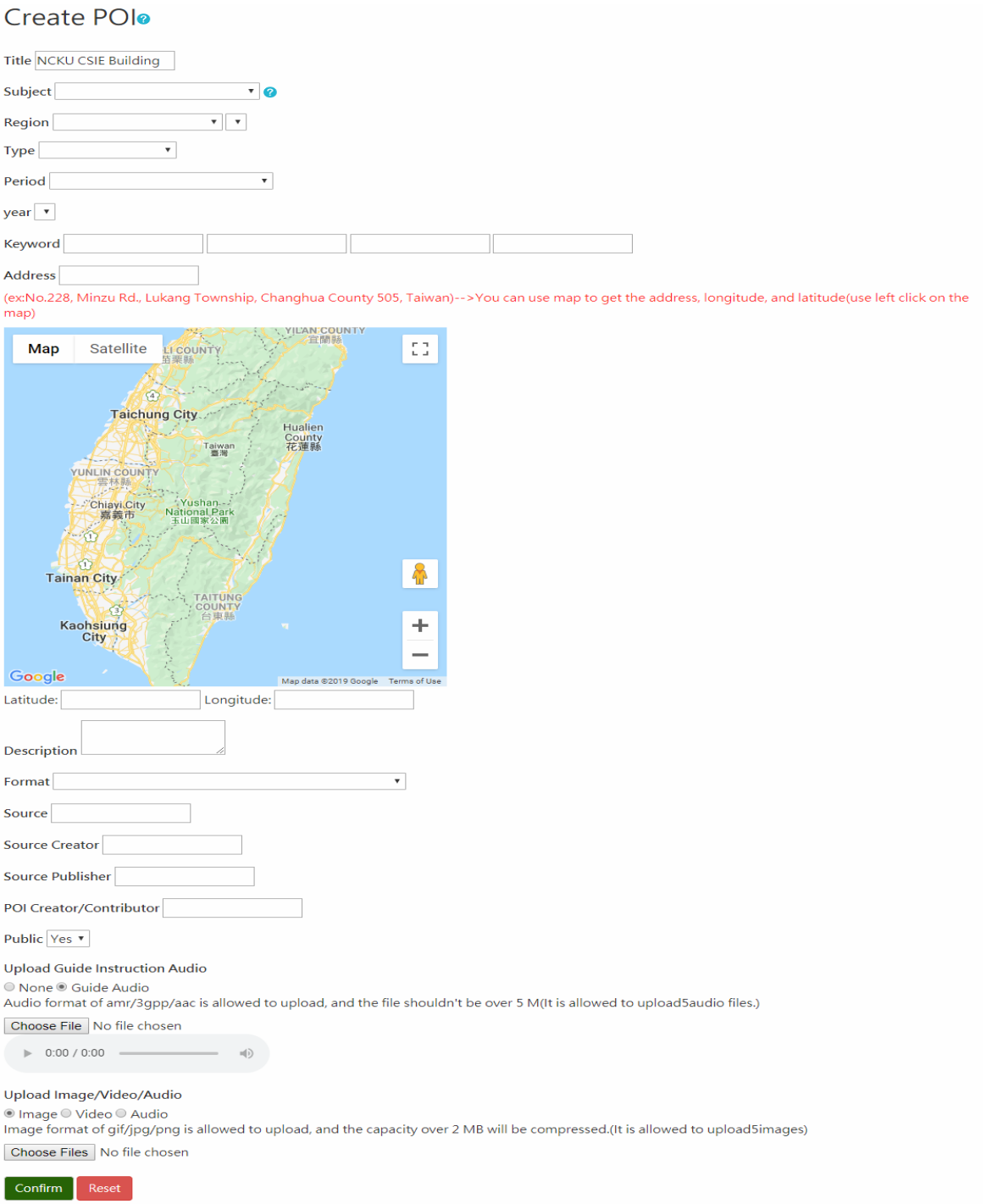

Figure 3. POI's authoring page

The example of creating an SOI is illustrated in Figure 4. The creating of a LOI (AOI) is similar to the one for SOI.

The exploring sub-system can redirect from the DEH homepage, for which users can specify the role of the Exploring map i.e., *player* map, *docent* map, and *expert* map, to view the contents made by regular users, narrators and experts respectively. The exploring sub-system provides three ways for users to search contents:

(1) **Set filtering options.** Users can (i) select the category of each content, i.e., POI, LOI, AOI or SOI, and the region, which are required, and (ii) set the other filtering criteria, i.e., Subject, Type, Format and/or Media Type, which are optional; then the server side delivers the filtered results, which are displayed on web pages. An example of searching POIs using the exploring sub-system is illustrated in Figure 5.

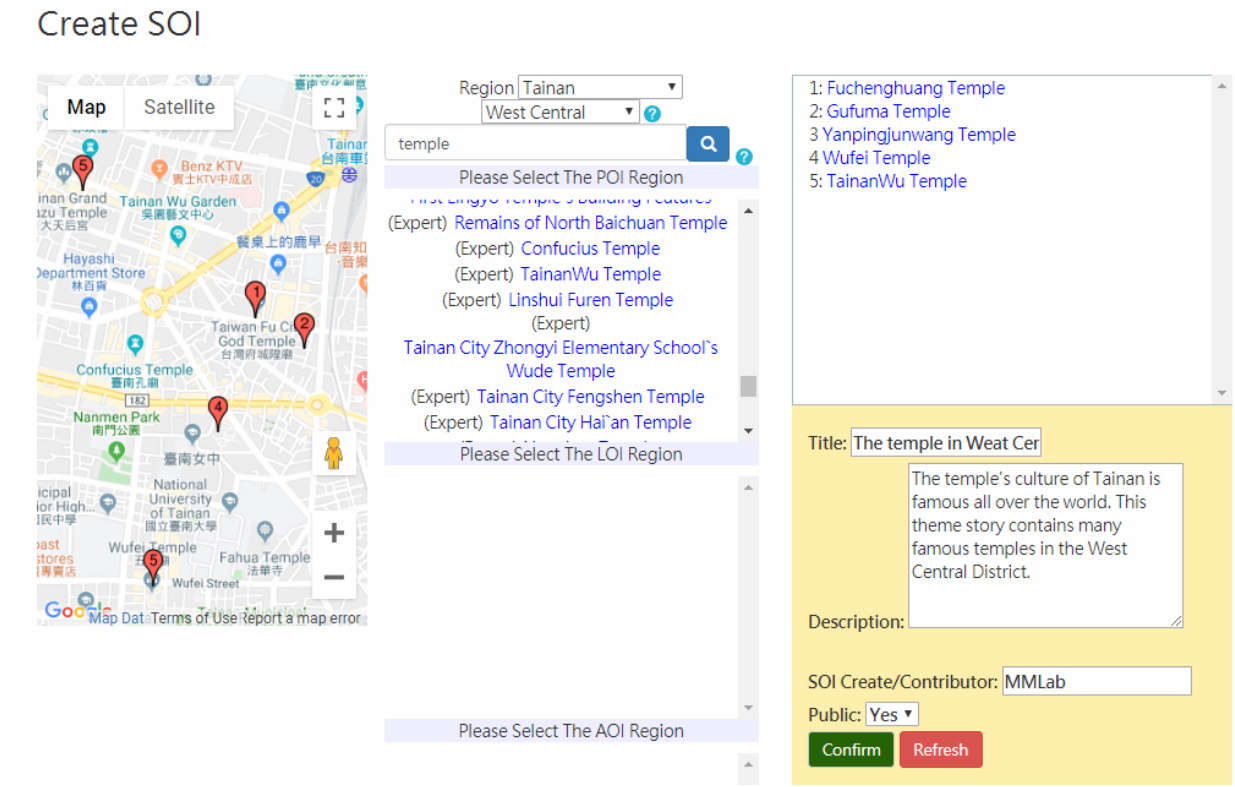

Figure 4. SOI's authoring page

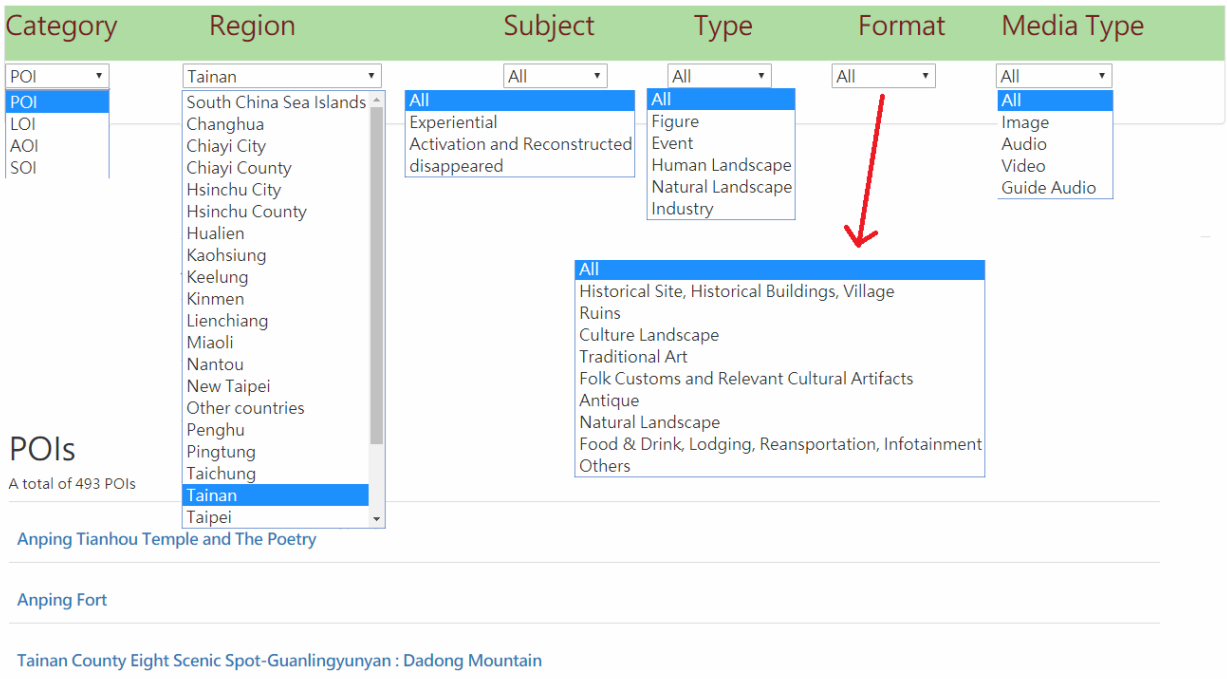

Figure 5. An illustrated example of setting filtering options for exploring on the DEH web

(2) **Text searching.** the other option is using keywords to search.

(3) **Advanced searching.** The third option is combining both filtering attributes and typing keywords to search.

The grouping function contains two aspects, which are (i) creating a group and (ii) group management. An example of creating a group is illustrated in Figure 6.

The exploring sub-system can display the content based on the role of content's author. Exploring a LOI, in which the author is the role of e*xpert/player*, is illustrated in Figure 7; exploring a LOI, whose author, i.e., a narrator, has the role of *docent*, is illustrated in Figure 8.

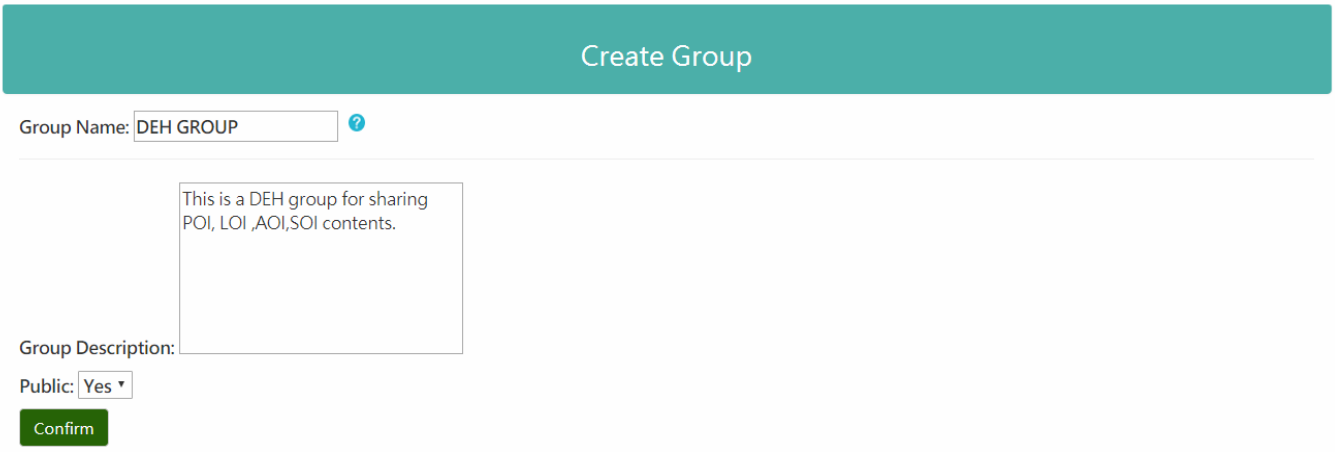

Figure 6. An illustrated example of creating a group in DEH's web system

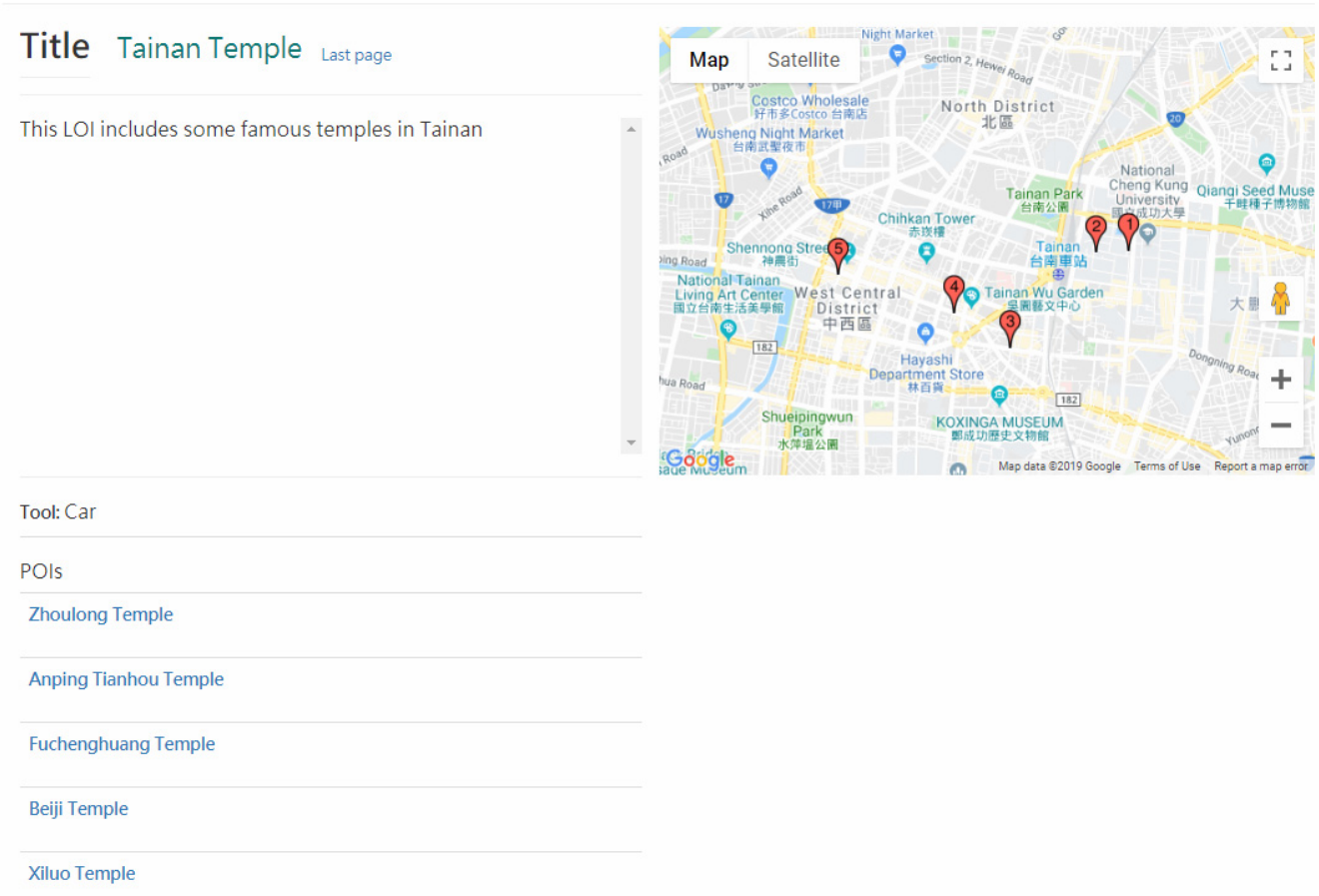

Figure 7. Exploring player's/expert's LOI on the DEH website

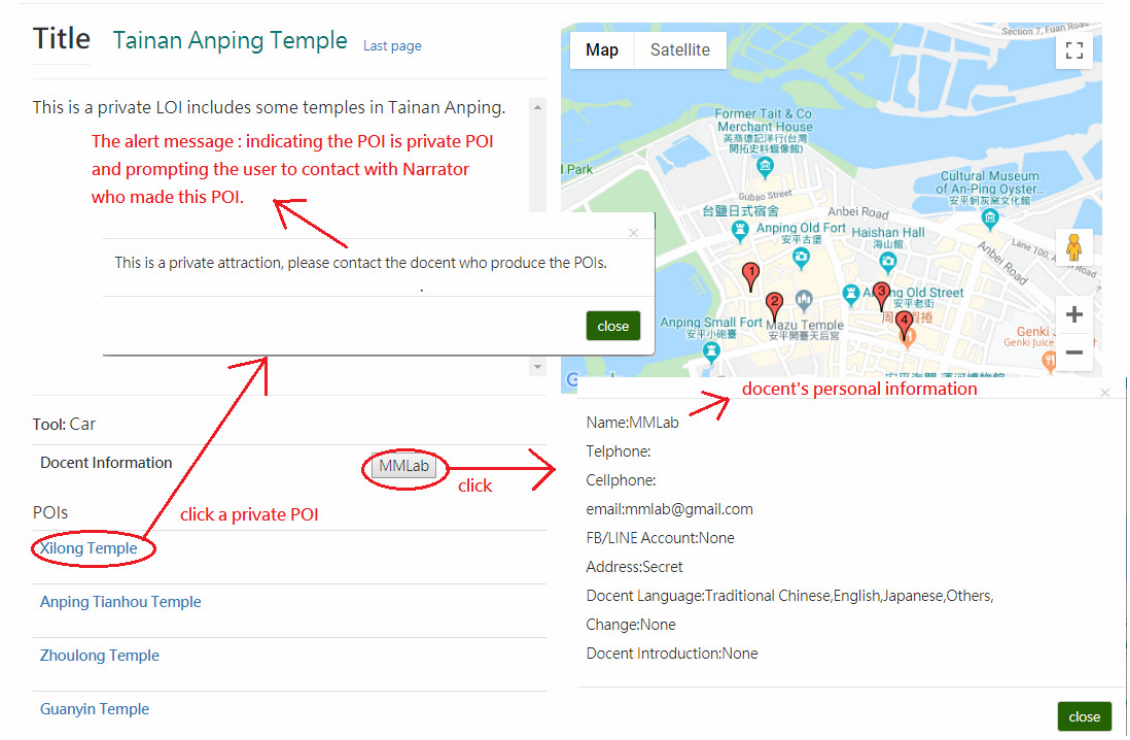

Figure 8. Exploring docent's LOI on the DEH website

The grouping function provides the services for group creator/leader to invite/kick out members, share/modify contents and edit group information. An example of how group creator/leader manages the group is illustrated in Figure 9.

The other management page of grouping is depicted in Figure 10. The **Notify** button shows the number of request-to-join messages or invite-to-join messages. The **Explore** button makes users be able to search the public and successfully verified groups that exist in the DEH platform. The **Manage** button can redirect into the initial management page, which is illustrated in Figure 10, that can get the information of the group. The **Disband** button allows group creator/leader to disband this group. The contents do not belong to any group any more before the user shares the content again. The Invite button can invite users to join the creator/leader's group.

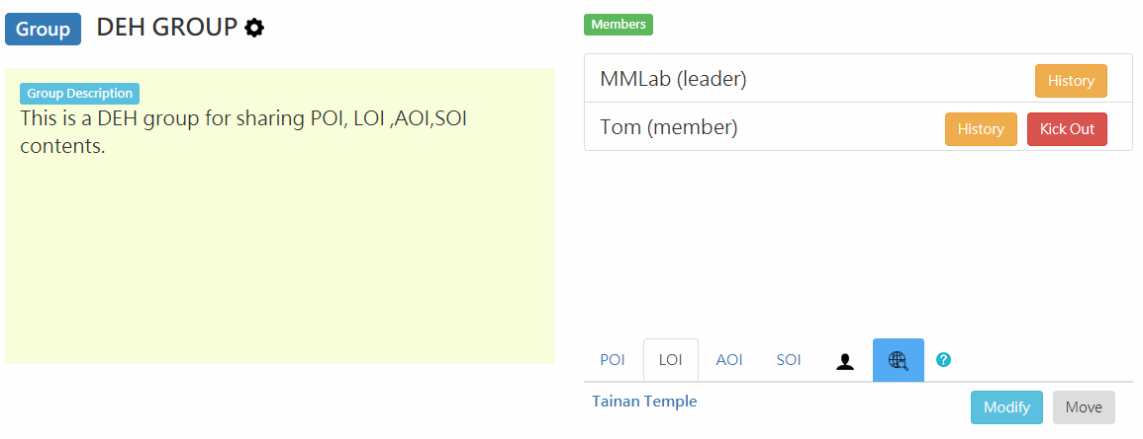

Figure 9. An illustrated example of the group management

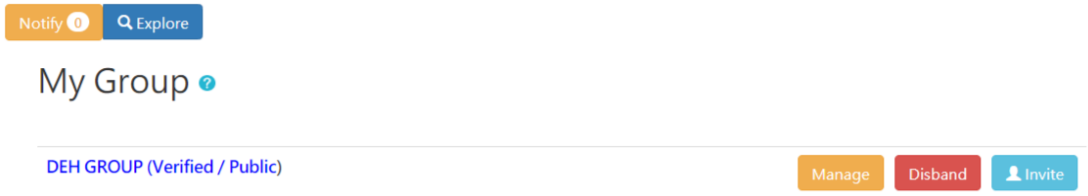

Figure 10. The other management page of grouping

In the DEH APP, a user can create POI and automatically get the latitude and longitude using the GPS that is in the smart phone. Figure 11 illustrates the steps for creating a POI using the APP of iOS's DEH Make. Figure 11(a) shows the functional buttons when the DEH Make is initially enabled. Figure 11(b) shows an example of creating an image POI. Figure 11(c) show that the image file can be (i) created using the camera of the handheld device that is executing DEH Make or (ii) selected from the Album, i.e., that was created before and is already available.

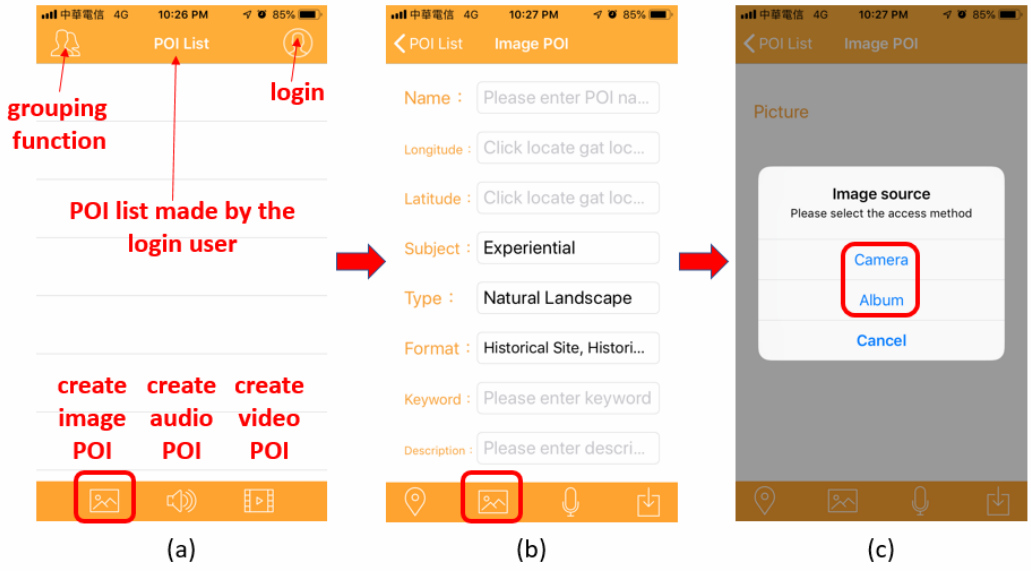

Figure 11. The authoring example of using the APP of iOS's DEH Make

After using the APP of DEH Make to upload a POI, which is attributed as "public", and have the successful verification, the POI can be displayed on the APP of DEH Mini. DEH Mini is the DEH exploring APP that supports the LBS service. Figure 12 shows an example of using Android's DEH Mini. Figure 12(a) shows the search of nearby POIs; Figure 12(b) shows the search of nearby LOIs made by the login user; Figure 12(c) shows the groups that the login user has joined.

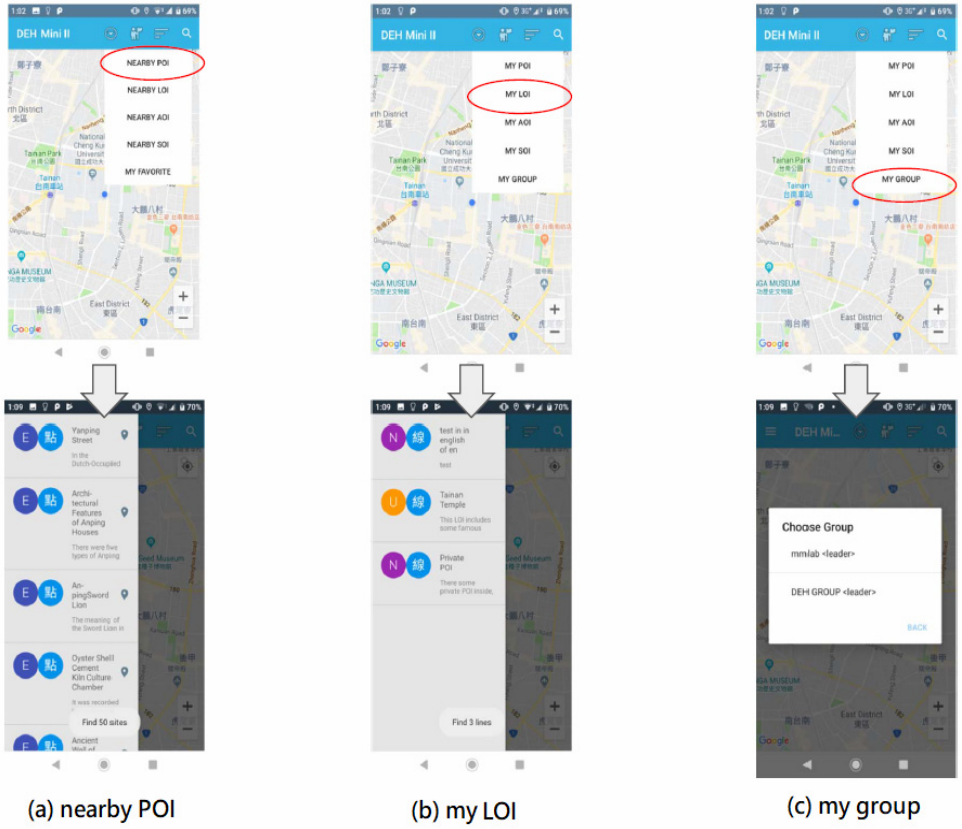

Figure 12. Get user's contents on the APP of Android's DEH Mini

Both DEH Make and DEH Mini have the grouping function. DEH Mini is able to view the contents belonging to the group that the login user has joined. DEH Make is able to (i) create a group and (ii) specify to which group the authored POI belongs. Figure 13 depicts the situation of creating a group using iOS's DEH Make. Figure 13(a) shows the currently groups that the login user has created or joined. Figure 13(b) shows creating a new group by the login user. Figure 13(c) shows the group list that the login user has created or joined after a new group has been created. The group creator/leader can invite users to join his created groups. Users can get the notification of grouping messages, i.e., request-to-join and invite-to-join, in DEH Make. Figure 14(a) shows that a request-to-join message has been received. Figure 14(b) shows that user "ray002: has the request-to-join for a group that the login user has created. Figure 14(c) shows that the popup window that allows the group leader, i.e., the login in user, to accept or reject the request to join group "mmlab".

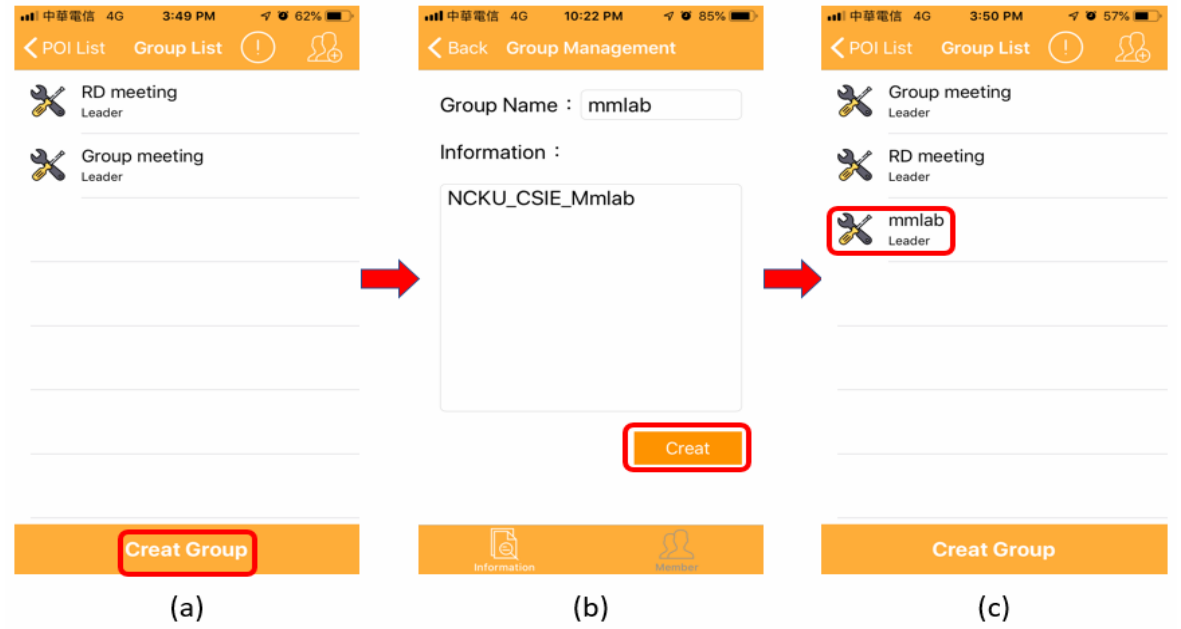

Figure 13. The authoring example of using the APP of iOS's DEH Make

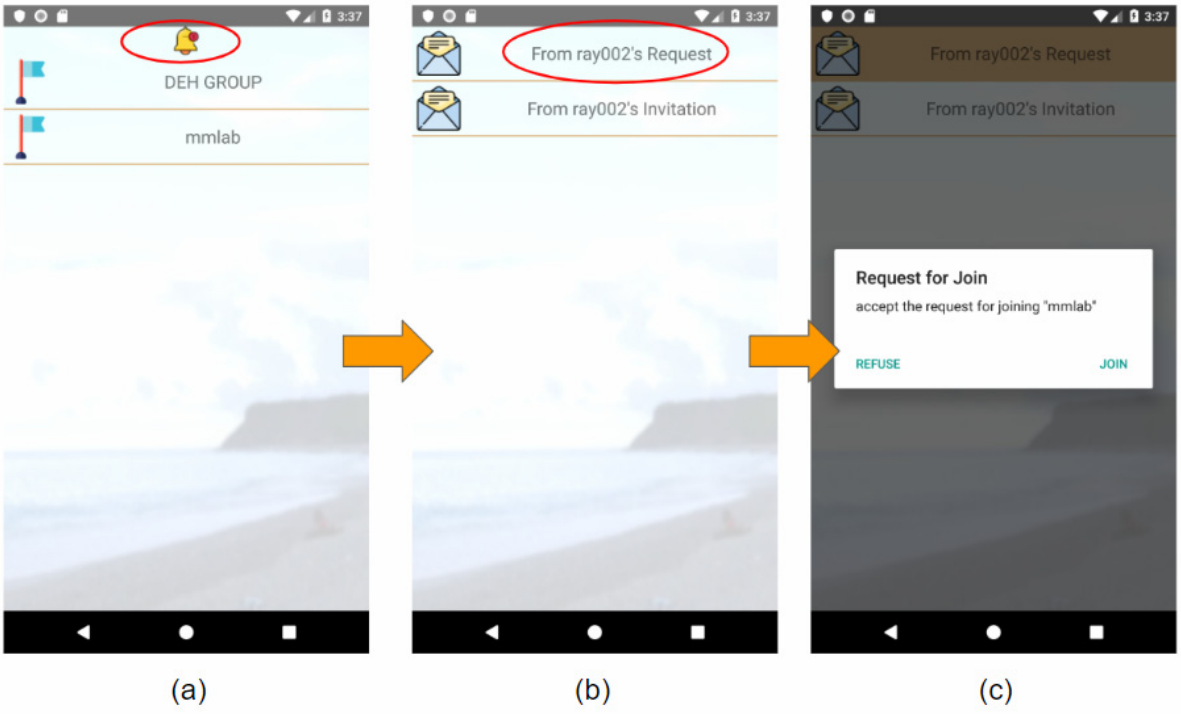

Figure 14. Notification of the grouping message on the APP of Android's DEH Make

The usage of Android's DEH Mini is illustrated in Figure 15. A user of DEH Mini can explore the nearby contents using GPS positioning or randomly select a center point on the Google map to search interested area.

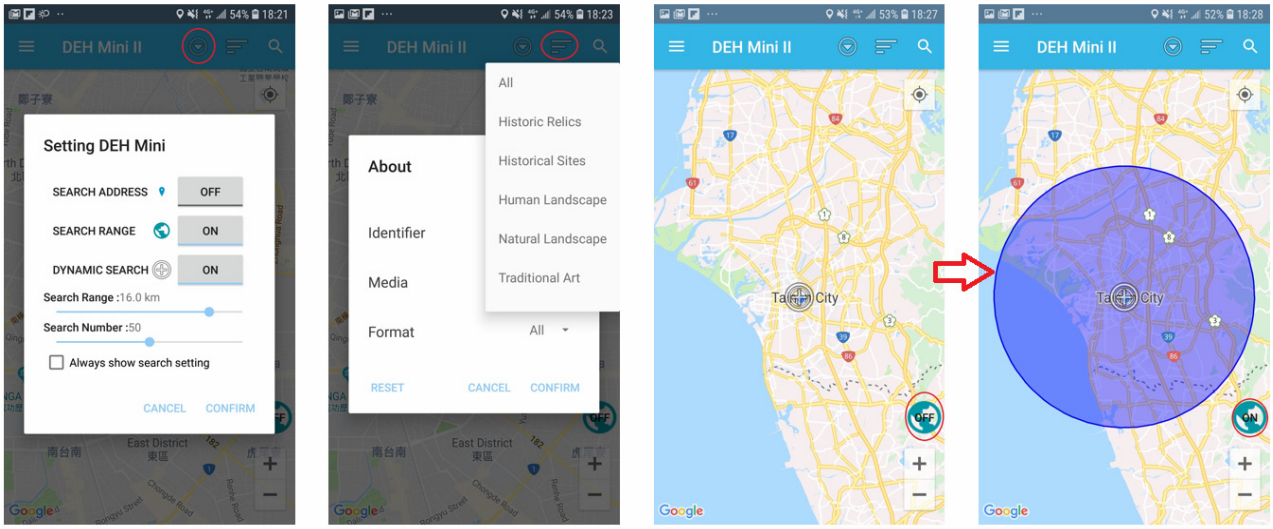

Figure 15. Exploring contents on the APP of Android's DEH Mini

8 Discussion and Conclusion

This paper has presented details of the work for developing the proposed Demodulating and Encoding Heritage (DEH) platform. The proposed DEH platform (1) preserves the information and contents of POIs by utilizing the simple Dublin Core Metadata element set and the additional metadata elements that are needed for M-DCH, (2) defines LOI, AOI, and SOI, which can be formally described using the corresponding proposed metadata elements, for users to author and explore M-DCH. Some technical functions that DEH has provided are the verification function and the grouping function. To achieve the aforementioned services, DEH web API and mobile API functions have been defined and implemented in this work. For the system usage aspect, the authoring sub-system allows users to register their accounts and then create their own contents; the exploring sub-system allows users to (1) set the filtering options, (2) have text searching and (3) set filtering options plus text searching to search interested contents more precisely. The verification function sets the verification status of the contents, for which public and successfully verified contents can be displayed on the exploring sub-system for all users. The grouping function allows (i) a number of users to share their own contents in a group and (ii) the group creator/leader to manage the group and modify the contents authors by group members.

Table 10 shows the comparison of different DCH platforms that are used to compare with the proposed DEH platform. Most of currently existed DCH platforms offer the service for POIs exploring with different characteristics. The Cultural Heritage Guidance [14] and Sightsmap [15] contain websites and APPs that offer the temporal route planning, for which Cultural Heritage Guidance allows users to select two POIs and calculates the shortest or best route and the Sightsmap allows users to choose several POIs temporarily, which is similar to a LOI of DEH. Culture Trip [16] contains a website and an APP and OkGo [17] contains a website, for which both of them belong to the blog-like platform where users can read an introduction of a specific location or particular activity that contains images, videos, and text. RoadTripper [18] contains a website and an APP, which is suitable for travelers to plan her/his own travelling route in advance. The trip can also be shared to other users in the website or APP. Users can easily search POIs and LOIs according to the classified options, e.g., restaurant, shopping or popular sites. BackPacker [19] is a website, which allows registered users to co-edit a POI, that is similar to the mechanism of Wikipedia [20]. ESRI's ArcGIS [21] allows users to build their own customized maps, which are presented like a story with a series of text and multimedia, e.g., images, video or 3D scene. ArcGIS users that are in a group can create contents on the customized map.

Table 10. Comparison of the DCH platforms

Features	Exploring				Authoring	Verification	Grouping	APPs	Cost
	POI	LOI	AOI	SOI					
Cultural Heritage Guidance [14]	Yes	Yes	No	No	No	No	No	Yes	free
Sightsmap [15]	Yes	Yes	No	No	No	No	No	No	free
Culture Trip [16]	No	No	No	No	No	No	No	Yes	free
OkGo [17]	Yes	No	No	No	No	No	No	No	free
RoadTripper [18]	Yes	Yes	No	No	Yes	No	No	Yes	free
BackPacker [19]	Yes	No	No	No	Yes	Yes	No	No	free
ArcGIS [21]	Yes	No	No	No	Yes	No	Yes	Yes	Charged
DEH	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	free

The main future work of the DEH platform is twofold: (1) adding the Pokemon GO-like interactive functions and (2) automatically verifying the contents and automatically classify the subject, type and format of a POI using the AI technique.

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