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A Robust Location-based Augmented-reality System for Supporting Inspection of Power-distribution Facilities

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1. Introduction

It is important for power-distribution departments to improve efficiency of maintenance works. Conventionally, high reliability is ensured by inspecting distribution facilities. Inspection workers should inspect the facilities while referring to related information such as inspection history, facility attributes, and past pictures to judge a facility's condition accurately. It is, however, difficult to identify the facilities and to retrieve the information from a database because an enormous number of facilities are scattered widely.

In light of the above-described issues, therefore, an augmented-reality (AR) system for supporting inspection is proposed, implemented, and tested. By means of the proposed system, the facilities viewed through a camera mounted on the tablet are identified by the proposed robust identification algorithm, and related information is overlaid on a live camera view. The robust identification algorithm, which is an advanced approach for conventional location-based methods, only uses GPS data as well as data from acceleration and geomagnetic sensors. The facilities can be identified robustly without being influenced by the measurement errors of these sensors.

In this paper, a robust identification algorithm and a prototype AR system are proposed in the following sections. Furthermore, the evaluation results are presented

2. Technical Requirements and Objective

AR technologies are classified as location-based methods or vision-based methods [1][2]. Location-based methods identify target objects on the basis of a device's location and heading obtained from some sensors. While such approaches have a merit of low computational cost, their identification accuracy is low because of measurement errors. It is especially difficult to display accurate information when location-based methods are applied to power-distribution maintenance because an enormous number of high-density facilities are scattered widely.

Vision-based methods, on the other hand, identify target objects using features obtained from images. Moreover, they can be categorized as either of two approaches: marker-based or marker-less. In case of marker-based approaches, the target objects are identified by recognizing artificial markers. Applying marker-based approaches to power-distribution facilities seems a distant prospect because an enormous number of markers are required. Marker-less approaches, in contrast, use natural features extracted from captured images. It is difficult to identify target objects in real-time because of the high computational costs incurred. It is also difficult to maintain high accuracy under a wide range of conditions such as differences in the weather.

Therefore, in this study, a robust identification algorithm—which is improved in comparison with conventional location-based methods and is easy to implement on general-purpose tablets—is proposed.

3. Robust Location-based AR system

3.1 Robust Identification Algorithm

The algorithm can realize robust identification by using not only a current location and heading but also object distance (i.e., the distance between the user and the object being inspected) obtained by triangulation using data from acceleration and geomagnetic sensors.

The identification process consists of three "narrowing-down" steps. Examples of the first narrowing-down steps are shown in Fig.1(a). In Fig.1(a), it is assumed that the user exists somewhere inside of the error range of GPS location, and turns in the direction indicated by the error-containing heading angle. The target that the user is viewing is therefore actually located inside of the shaded area in Fig.1(a). The facilities located inside of the shaded area are extracted as the first candidates of the target facility.

The second narrowing-down step is performed to extract second candidates by using the object distance (Fig1.(b)). In this step, it is assumed that each facility in the first candidates is the target facility being actually viewed by the user. Under this assumption, the user's location in relation to each facility in the first candidates is estimated from the object distance and heading angle. It is checked whether the estimated user's locations are inside the error range of GPS location. If the estimated location is inside the error

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range, the corresponding facility is extracted as one of the second candidates for the target facility.

If the second candidates contain some facilities after the second narrowing-down step is finished, the third narrowing-down step is performed using GIS data. In the third step, the candidates for the target facility are narrowed down from the second candidates by checking the validity of the estimated user's locations. For example, if there is a building between the facility and the estimated user's location, the user can not view that facility.

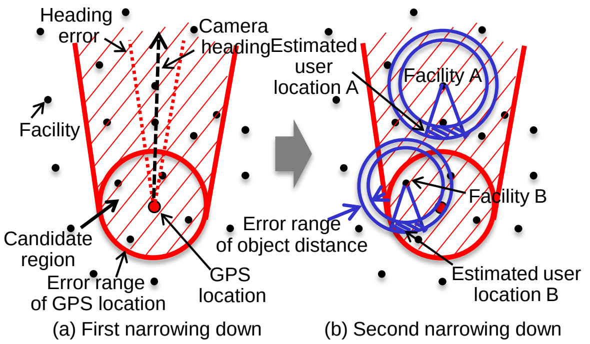

Fig.1 First and second narrowing down steps

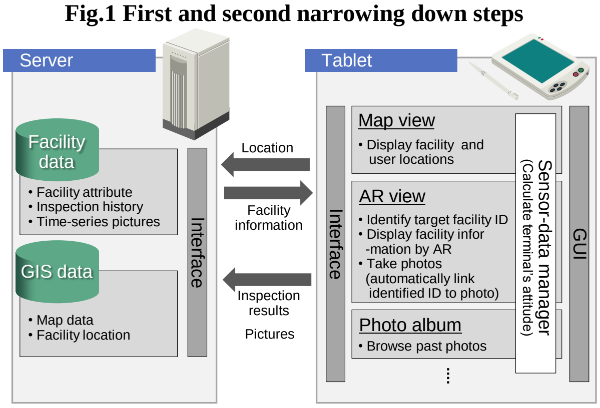

Fig.2 System architecture

3.2 Prototype System

The architecture of the AR inspection-support system is shown in Fig.2. The server holds databases of facility data and GIS data. This facility database stores inspection history, facility attributes, and facility's time-series pictures. The locations of the facilities are managed in the GIS database. The tablet-side application consists of a map view, an AR view, a photo album, and some functions for supporting facility inspections. The map view displays the facility's locations on a map. In the AR view, the target facility is identified by the proposed algorithm, and related information is overlaid on a live camera view. Furthermore, taken pictures can be browsed in the photo album. Finally, the pictures and inspection results are uploaded to the server and accumulated in the database.

4. Evaluation Results

The proposed algorithm was experimentally evaluated in the field. The field experiments were performed at 34 places in Tokyo. The average of the measurement errors of GPS location and user's heading were 10.0 m and 10.44 degrees respectively. Fig.3 shows some examples of experimental results. In this case, nevertheless the actual user's location and GPS location differed significantly, the facilities were identified correctly without being influenced by the measurement errors. Results of the field experiments show that the proposed algorithm uniquely identified the target facility at a success rate of 90%.

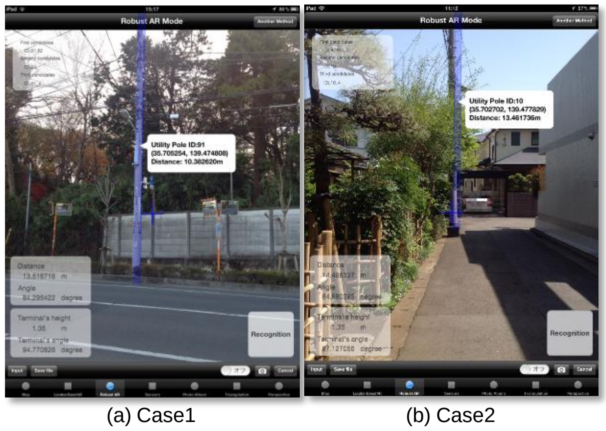

Fig.3 Examples of experimental results

5. Conclusion

A robust location-based augmented reality (AR) system for supporting inspection works for power-distribution facilities was proposed. By means of the proposed system, the facilities viewed through a camera mounted on the tablet are identified by the proposed robust identification algorithm, and related information is overlaid on a live camera view. The robust identification algorithm, which is an advanced approach for conventional location-based methods, only uses GPS data as well as data from acceleration and geomagnetic sensors. The facilities can be identified robustly without being influenced by the measurement errors of these sensors. Furthermore, a prototype AR system was developed and tested. Results of field experiments using the system show that the proposed algorithm can uniquely identify the target facility at a success rate of 90%.

In future work, the feasibility of the proposed system using a real facility's data accumulated by power utilities themselves will be demonstrated.

References

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