A SURVEILLANCE SYSTEM BASED ON SOCIAL NETWORKING AND LOCALIZATION

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ABSTRACT

Surveillance systems are developed to enhance security and safety by constantly observing locations of interest. Although those systems can observe scenes from each camera separately, it is difficult to keep track of any moving target across different cameras. This paper firstly proposes Video Diary Service (VDS) to solve this problem. VDS is an automatic diary service, which makes it possible to keep track of users' lives. In addition, VDS can identify social networking relationships among the users while each camera is watching multiple users. By exploiting these properties of VDS, we extend VDS into a new surveillance system called S-VDS. We also illustrate a few application scenarios where the proposed system can enhance security and safety.

Index Terms— Video, Diary, Social Networking, Location Based Service, Surveillance System

1. INTRODUCTION

Homeland security and public safety [1] are gaining more concerns from the viewpoint of governments, which are obligated to protect their citizens and critical infrastructures [2]. With an increasing demand to prevent unfortunate incidents (e.g., sexual crimes and missing children), surveillance systems are increasingly deployed in various fields including human activities, public places, forensic applications, and military operations [3]. As surveillance system has become one of the remarkable social infrastructures, academic and industrial communities have made great efforts to develop sophisticated surveillance systems [3, 4, 5].

The rapid advancement of video-processing algorithms has brought significant changes in the landscape of surveillance systems [6, 7]. Starting from the very primitive level of surveillance like just taking pictures from a few cameras in a small area of interest, the recent surveillance systems monitor a wide area and identify a specific target accurately in an automatic and efficient fashion [8]. However, there is a limitation in current surveillance systems figuring out what happened to the target moving across multiple cameras. This is because most surveillance systems are focusing on what happened from the sight of each camera.

To solve this problem, we firstly propose *Video Diary Service (VDS)*, which allows users to post video images as they move across multiple cameras. In this way, VDS can keep track of the users' location as well as the users' video images. It is developed for the purpose of an automatic creation of personal diaries including video contents. Since the system is focusing on the users, not the area, we suggest that VDS be applied to a surveillance system that keeps track of a specific target across multiple cameras.

The proposed system, *Surveillance system on VDS (S-VDS)*, retains three properties of VDS. Firstly, personal information (e.g., location, time, and preferences) of a moving target is used. Secondly, social networking relationships among VDS users are exploited to enhance the surveillance functionality. Finally, video images are recorded for the purpose of supervision/archival. We assume that the location of a specific target can be figured out at the granularity of the areas covered by each camera. In the literatures, there have been many positioning algorithms with sufficient resolution by relying on GPS and/or network-based localization techniques (e.g., WiFi, cellular, and RFID).

We make the following contributions: (1) to the best of our knowledge, this is the first work that explores the possibility of using social networking and localization for surveillance. (2) We develop and demonstrate a novel service, VDS [9]. (3) We extend VDS into S-VDS to serve as a new surveillance system. (4) We suggest a few application scenarios that can be applied to S-VDS.

The remainder of this paper is organized as follows. Section 2 introduces VDS. Section 3 explains how to extend VDS into S-VDS. After illustrating possible application scenarios to apply the proposed surveillance system in Section 4, we conclude this paper in Section 5.

2. VIDEO DIARY SERVICE (VDS)

Microblogging services such as Twitter [10], Facebook [11], or Myspace [12] are killer applications in social networking field, especially as mobile smart-devices such as Apple iPhone, Samsung Galaxy-S, and Apple iPad become widespread. These services allow users to express their thoughts and feelings by using simple texts and images. Considering the recent trend that demands to express not only just thoughts and feelings but also their whole life is getting stronger, we believe a novel service called Video Diary Service (VDS) may emerge to satisfy the needs to expose their

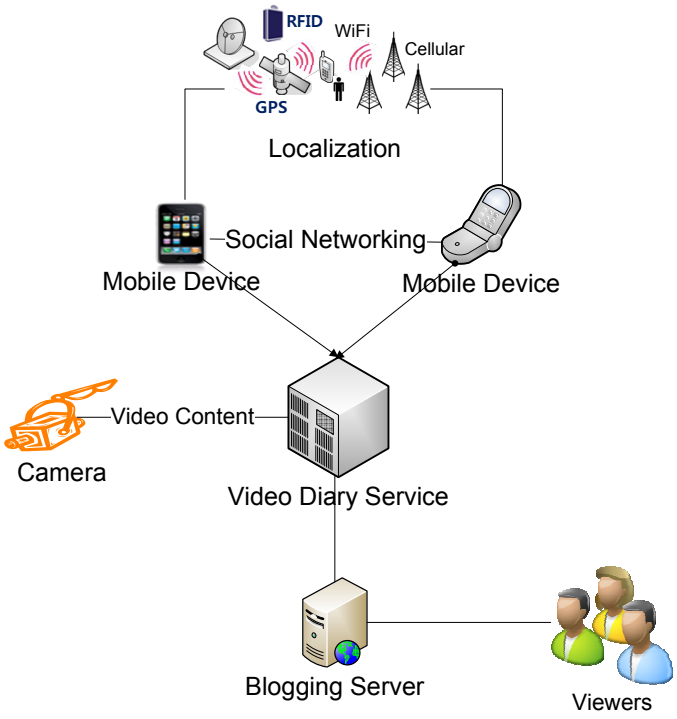

Fig. 1: The Illustration of Video Diary Service

lives easily. Figure 1 briefly illustrates VDS.

In VDS, a user diary is a video-based archive that records the user's daily lives automatically depending on predefined preferences. Mostly, the diary consists of video images but other information such as memos and pictures can be added. To make a diary for each user, VDS needs to find out two things: (1) the location of each user for each period, and (2) the user's video images for the corresponding period. Firstly, in order to find the location of the user, localization techniques in many location based services (LBSs) [13] can be applied (e.g., GPS-based or network-based localization). Then, with the information on location and time of the user, VDS retrieves the corresponding video content from video databases and posts it onto the user's blogging server. We assume that a sufficient number of cameras including public CCTVs are already deployed over the area of interest.

In addition to information on location and time, some extra information such as spatial semantics (e.g., museum and airport) can be provided to enrich diary contents in VDS. For example, when a user visits a museum, VDS provides not only video images but also the tagging information like 'museum' at the moment. One of the key functions in VDS is to identify social networking relationships among users, based on their locations at each moment and other tagging information in an automatic fashion. For example, two users seen by the same camera at the same time can be linked via a social network. There can be other promising application scenarios such as a conference/exhibition report, a remote care system, and a baby diary.

The presentation of VDS somewhat resembles that of social networking services. VDS provides a sequence of video data with extra information as a diary article. For this purpose, VDS configures users' preferences in advance. The automatic inscription of articles is done according to the previously defined configuration (e.g., record with 24-hour interval vs. record only in working time).

We developed and implemented VDS. Readers may refer detailed system descriptions including a demonstration video in [9]. The illustration of our developed system is shown in Figure 2. The leftmost figure is a snapshot from a CCTV screen. Then, the surveillance version of VDS manipulates the video recorded by the camera. As a result, VDS provides a video diary with rich information as shown in the rightmost figure.

3. SURVEILLANCE SYSTEM ON VIDEO DIARY SERVICE (S-VDS)

Since VDS records a sequence of video and additional tagging information, and connects people with common interests, it can be said that it is promising to build a surveillance system based on it. In this section, we propose a novel surveillance system called S-VDS, which is based on VDS and can keep track of any moving target, (e.g., a specific user in VDS) in the service area.

3.1. The Overview of S-VDS

S-VDS is composed of Location Management Server (LMS), multiple cameras, a video server, Video Diary Agent (VDA), Social Networking Management Server (SNMS), Surveillance Agent (SA), and Surveillance Report Server (SRS), as described in Figure 3.

When a specific target with a mobile device enters the service area of the system, its location is identified by using localization techniques based on wireless networks such as wireless LANs, WiMax, or cellular. Then, LMS records the location information (e.g., the identifier of the camera watching the target) with time information on its database.

Cameras are located at fixed regions and continuously send video images to the video server. The video server adds location and time information to the video data. Optionally, the tagging information, if any, can be added.

Then, links to the video images are sent to VDA automatically. VDA contacts LMS to get the location of the target captured in the received video images. In case where there are multiple targets at the same location and time, the information of the targets and tagging information of video images are sent to SNMS.

SNMS identifies social networking relationships among targets by analyzing information sent from VDA. For exam-

Fig. 2: Demonstration of VDS. The recorded video images are turned into a video diary article through Video Diary Service.

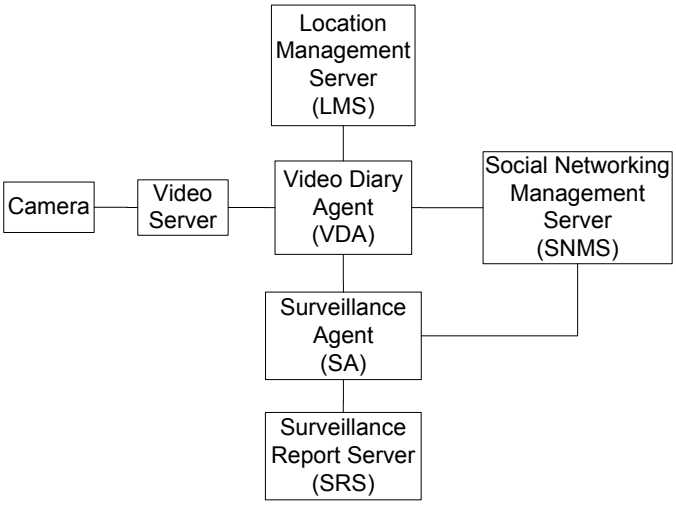

Fig. 3: The architecture of S-VDS

ple, if two targets are simultaneously seen from the same camera at the crime scene, the relationship between the two targets is crucial for surveillance.

Based on the information from VDA and SNMS, SA analyzes and provides the comprehensive information of the target under surveillance. Depending on surveillance purpose, video diary articles and their associated social networking relationships are exploited suitably.

Finally, SRS provides an easy lookup system for law enforcement agencies. It decorates the received information including video contents by transforming them into a posting form, and publishes the product to the public. SRS provides a list of diary articles written with the target information provided by SA. It creates a page with decorations suitable for a diary article, containing all contents it got from the previous work. Because *http* protocol alone is not enough to present video content, SRS also uses applications like Flash or Silverlight [14].

Since VDS has many properties that can be used for surveillance, it can be easily turned into such system. To try not to miss any scene as long as the target is under the coverage of the system, S-VDS chases the location of the target and the related information such as corresponding video contents that can be used for surveillance purposes.

3.2. Location Management

When a target appears in the coverage of the system with a mobile device, the target's location is identified by localization techniques. Since most of current mobile phones include GPS modules, the target's location in outdoors can be estimated accurately. To provide localization in indoor environments where the GPS signal is too weak, network-based localization techniques can be applied to various wireless networks – cellular, WiFi, sensor and RFID [15, 13, 16, 17, 18]. Received signal strengths (RSSs), which are reported by mobile devices to the LMS in the system, are commonly used in most network-based localization.

Upon receiving the reports from the mobile device, LMS estimates the location based on localization techniques. To improve accuracy in the estimation or avoid miscalculations due to wireless signal fluctuation, LMS also uses the location history since LMS continuously keeps track of the target's locations. LMS manages a location list of the target as long as the target is under the coverage of the system.

3.3. Video Content Production

The video content of VDS is produced by public cameras (e.g., CCTV) and managed by the video servers. The cameras are recommended to deliver and process the data in real-time. The data with a short duration (but still enough for surveillance purpose), are sent to one of the video servers in the system. The video server stores the most recent data and makes it into a video periodically. Upon creation of the video, the video server triggers the encoding module. The video then gets encoded to be published on the web. Since every single computer environment will not be able to decode the com-

pression of each camera from different manufacturers, encoding the video into a common codec is necessary. Since a Flash player is installed in most computers, turning a video stream into a Flash file is most desirable, but this will not be easy because of the codec license. Making it into Windows Media Video (WMV) and using Silverlight [14] to play on the web can be a good alternative; we adopted this option. After encoding the video data, the video server puts appropriate tagging information to the video content. The tagging includes not only information on location and time of the video data itself but additional ones related to the location itself to give rich information on the scenery for the viewers.

3.4. Merging information and Forming Social Networks

While LMS estimates the target's location and the video server manufactures publishable video contents, VDA manages the entire system to help parts of the system to communicate with one another. On periodic creation of a diary article, VDA refers the location and time of the target and figures out which camera would have taped the appropriate video data. Once the calculation is over, VDA seeks the video content that best fits to the article. With the information from LMS and the video server, VDA finalizes the diary article, which includes the video content, the user information, and additional information related to the location.

To enhance surveillance, SNMS forms a social network among the target and other targets automatically. Based on the target information from VDA, SNMS analyzes relationships among the targets for the surveillance purpose. The surveillance system can fully utilize the relationships to enhance safety. For example, there are two people in the scene. One target is a child and the other target is a child sex offender. If they are in the same place at the same time, the surveillance system automatically connects two targets with their tags: location, time, and the subject 'child sex offender'. This kind of social networking information may help to protect children or provide a forensic evidence for police investigation.

3.5. Surveillance Management

Differently from original VDS, S-VDS puts an additional effort for surveillance. Since this is a surveillance system, an automatic form of reporting is more likely than responding to requests. For this reason, SA firstly looks at the information provided by VDA. It analyzes the device identifier, location, time and attached tagging information. The analysis is based on previous data or databases from external systems like criminal record databases. In this way it can prioritize video diary articles in the order of importance, or it can even detect possible dangers. If necessary, it can alert relevant people as quickly as possible. For example, SA can compare the result with criminal records and decide to alert people near the criminal.

Finally, SRS plays a role as a publishing entity of the system. It gathers up all the previous information from SA and applies it to each presenting format. The formats are not restricted to web services and can be extended(e.g., for mobile devices). It can also alert people possibly in danger since SA can let SRS know the possible dangers.

4. APPLICATION SCENARIOS

In this section, we suggest and explore three application scenarios which raise possibilities of S-VDS.

4.1. Remote Healthcare

Some people like the elderly, the handicapped, and patients need to be taken care of by others [19]. Their health is jeopardized by malfunctioning of the body and diseases. They need constant cares and immediate treatments in emergency. However, in the real world it is almost impossible to get ready to handle all situations all day long. In this case, S-VDS can be a good alternative. Since in most cases mobile devices can be together with the patients all the time, cameras can detect their movement successfully.

If additional features like healthcare sensors are directly attached to the surveillance system, it would be even more powerful. When accidents happened, the sensors with Internet connections would let the system know abnormal activities happened to patients and automatically alarm people who are responsible while the surveillance system gathers information to form a video diary. They are able to watch the real-time video as well as stored video diaries of the patient. Meanwhile, social networking in the system will let relatives know that an accident had happened. The quick response to the emergency shortens the time gap between the moments of the accident and the treatment, and it remarkably weakens the level of danger.

4.2. Anti-crime Effect

The usage of S-VDS can be a huge threat to potential criminals. It not only records sceneries like previous surveillance systems but also provides an easy lookup system for law enforcement agencies. They are also able to watch the real-time video of the incident. By just picking up the video diary articles related to the crime scene, the agencies will easily acquire clues. As tracking the criminal's path from nearby cameras, the system alerts people near the trace of the criminal or calls for their help by using social networking. Even if the system loses the criminal, it is still useful since people interested in the crime scene or at the same location can communicate and help the police to track down the criminal. Specializing S-VDS to an anti-crime surveillance system will even strengthen the system. By applying anti-crime devices instead of normal mobile devices, the system will have better

chances to detect crime scenes. Irremovable detecting devices attached to sexual criminals can be a perfect example of applying anti-crime devices. They let the system know the exact position of the criminal. Eventually, they can alert the police a crime scene and build video diary articles about the scene as quickly as possible.

4.3. Finding Missing Children

Video data taken by S-VDS can help to those who are desperate to find their missing children. If parents gave some mobile devices to their children in advance, the parents do not need to worry even when they lose their children. Information on location constantly lets the system know where children are and deliver the video sceneries near the children. The place information will be greatly of help to guess the exact location of the children since tagging includes nearby places like famous stores, public places and so on. The SNS built in the the system can also show its powerful functionality in this case. It calls and asks for people with the similar location tag to find the missing children. People knowing that they are near the lost children can communicate and cooperate to find the children. This usage of the system is also applicable to looking for missing pets.

5. CONCLUSION

This paper firstly describes a service application called VDS, which was originally developed for a diary service based on video contents. To satisfy its original purpose, VDS tries to capture not only sceneries of a user all the time but also the trace of the user by localization techniques. By changing the system viewpoint from *sceneries* to *users*, VDS can successfully follow users even when they go out of the sight of each camera. Then, we suggest applying VDS to the surveillance field and see its potential as a surveillance system because current surveillance systems are not suitable for moving targets across multiple cameras. We also show that S-VDS can be put into practice in various situations. However, the system is still imperfect in a point that it may raise privacy issues. If the community succeeds to deal with these privacy issues, S-VDS can not only succeed as a diary service but have a remarkable contribution to the surveillance field.

6. ACKNOWLEDGMENTS

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