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USING RFID SYSTEM TO ENHANCE MONITORING OF WILDLIFE ACTIVITIES

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Abstract

Wildlife observation is the study of wildlife organism/species with minimal disturbance to their ecosystems. Wildlife observation is time-consuming and quite a tedious activity. It involves capturing and recording animal activities spontaneously as the animals enter the observation study area. This does not always result in what the observer expects to capture or record, since it is quite difficult to predict when animals will enter the observation study area. For this purpose, efficient technology in the form of equipment is required for better wildlife observation. RFID facilitates the detection and identification of objects that cannot be easily detected by conventional sensor technologies, but it does not provide information about the condition of the objects. However, Wireless Sensor provides information about the condition of the objects detected. The integration of these two technologies expands their overall functionality and capability. This research develops a real-time prototype smart system to enhance the observation of the wildlife activities.

Keywords:Radio Frequency Identification (RFID), Wildlife Observation, Sensor Networks.

1. Introduction

There have been recent studies that facilitate the use of technology for animal observation; the technologies used involve the use of tools like cameras, sensors, and backend remote monitoring systems. In order to achieve accurate and efficient data capturing equipment, these tools need to seamlessly work and be connected to each other.

One of the growing and popular technologies in the Internet of Things (IoT) is Radio Frequency Identification (RFID) technology. The use of RFID tags and readers in collaboration with a backend system enables activities that involve identification, tracking, and monitoring; and one such activity is wildlife observation. Wildlife observation involves tracking and monitoring the occurrence of the targeted animals; and the integration of RFID technology with the equipment used for animal observation can enhance the overall process.

For the last two decades, camera trapping has become a very popular method for studying and observing wildlife. The wildlife spotting robot lags in sensing and camera triggering is required for waking up the camera and image capturing. There is a possibility of missing occurrence of capturing creatures between the triggering and waking up of the camera.

In this research, the issues found in the wildlife-spotting robot are taken under consideration and further developed. The implementation and testing of the proposed application has been a success in terms of the issues considered. This paper consists of 6 sections: Section1: Introduction, which includes the objective and scope of this research, an overview of RFID technology, an overview of the Wildlife spotting robot, a brief discussion about the related

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works; Section 2: Design of the system; Section 3: Implementation of the proposed system; Section 4: Limitations; Section 5: Conclusion; and Section 6: Future works.

2. The research satisfies the following conditions:

- It is specifically designed to wake up the camera before the animal or bird enters the observation area.
- It is designed for capturing the images of the animal or bird from different angles in the observation area.
- This system deals with:

    - Registering and unregistering the cameras.
    - Registering and unregistering the tags.
    - Reading the tag ID attached to the motion sensor.
    - Waking up the camera.
    - Capturing images.
    - Putting the camera to sleep when there is no camera activity happening.

3. Overview of RFID

Radio Frequency Identification (RFID), a wireless technology, uses low frequency radio fields for transferring data between RFID devices, which usually consist of chips attached to tags and a receiver with an antenna (Punit Dharani, 2012). It is one of the most popular identification systems, which uses radio frequency signal for transferring the ID and RFID-based information. It is used because it eliminates the line of sight requirement (unlike barcode system) and for its wireless capability (López, et al., 2011) It is basically automatic data capturing technology, which allows non-contact reading in fields of manufacturing, asset awareness, and in hostile environments where barcode labels cannot survive. It is mainly used for collecting data of products easily and quickly without any human intervention; data such as place, time, and transaction details.

One benefit of RFID over other forms of identification technology is that it operates on proximity instead of swiping or scanning. Depending on the type and range of RFID readers and chips, RFID devices can be read or scanned from as far as 100 meters to as little as a few centimeters. Due to its susceptibility to readers and tag collision, the exact frequencies of RFID tags are variable and can be configured in order to minimize interference from other electronics, including other RFID systems. Compared to passive tags, active and semi-passive tags are typically expensive and reserved for more advanced forms of asset management due to the costs of both battery and advanced internal hardware (Dharani, et al., 2012).

The use of RFID has cut down costs and is applied in various applications like smart homes, RFID-based attendance systems, for educational and observation purposes like marine observation, wildlife observation, human-dolphin interaction, etc. It has been a focal point of innovation for the last two decades.

4. Related Work

In Lin, (2003)a video surveillance camera was integrated with an RFID tracking system. Placing RFID tags in visually apparent locations of the surveillance area facilitated the calibration of the RFID tracking system. Vellidis, et al., (2007) developed a real-time, smart sensor array for measuring the soil moisture and soil temperature. The array includes a centrally located receiver, which is connected to a laptop computer, and multiple server nodes were installed in the field. The sensor nodes included up to three Watermark moisture sensors and up to four thermocouples, a specially designed circuit board, and an RFID tag for transmitting data to the

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receiver. The integration of sensors with precise technologies provides a closed loop system, wherein, inputs from the smart sensor array determine the timing and real-time-site-specific applications. Hamrita & Hoffacker, (2005) demonstrated the feasibility of RFID for wireless real-time communication with temperature sensor.

Cho, et al., (n.d.) designed an RE-transponder with temperature and photo sensors for environmental monitoring. They proposed a clock generator in order to reduce power consumption. Roy, (n.d.) developed a web-based graphical user interface for managing the data of pollution. Sensor nodes were used to read the current sensor reading. Mainwaring, et al., (n.d.) developed a system for sea-bird nesting and behavior monitoring where they use d sensor nodes to collect data online without disturbing the birds' life and routine.Naderipariz, (n.d.) introduced WISPCam, a battery-free camera based on the wireless identification and sensor platform. It transmits an image over a sequence of many smaller transmissions within the EPC Class 1 Gen 2 protocol. The developed camera makes battery-free image sensing feasible for wildlife monitoring.

5. Overview of the Existing System (Wildlife Spotting Robot)

The main equipment for wildlife observation is a recording device and the most commonly used recording device is a camera. Unlike the other cameras, wildlife observation requires a camera with specifications that involve certain parameters. As per Connolly, these include:

1. *Robustness:* Robustness comes into consideration since the camera will be used for outdoor wildlife recording. This also includes robustness of the memory, for instance, using a digital camera instead of a film based camera would provide memory that can withstand extreme conditions and can be used for a longer period of time (Shin-Ichi, 2010, p. 314).
2. *Frame rate:* Frame rate is required for acquiring detailed movement and image quality in order to capture events such as a bird flying in a narrow place and position. The high frame rate and resolution directly affects the next aspect (Shin-Ichi, 2010).
3. *Storage capacity and battery longevity:* The next aspect taken into consideration is, storage capacity. The bigger the storage capacity, the better it is for a long-term observation in the wildlife (Shin-Ichi, 2010, p. 308). Battery longevity, subsequence capture, and long-term observation can drain the battery; but storage and battery longevity can be optimized by using programming for capturing images with pause intervals and battery conserving sleep (Connolly, 2007).
4. *Camera wake-up time:* The wake up time of the camera is an important aspect for wildlife observation because the longer the camera takes to wake up, the higher the chances of missing the occurrence of the animal/ bird (Shin-Ichi, 2010).

Another piece of equipment that is used for wildlife observation is the sensor. Introducing a sensor to the observation equipment makes the equipment more intelligent and automated since the sensor will trigger the camera with signals to capture images or to make an optical adjustment. This reduces manual labor of capturing images or recording videos and also eliminates habitat disturbance due to human interference. (Connolly, 2007, p. 282)

There are various types of sensors used for wildlife observation; the most commonly used is, the infrared sensor. Both researchers, Connolly and Seki, demonstrated infrared sensor integrated with the camera for sensing a nearby animal, pointing the camera, and triggering image-capture. The existing equipment uses a sensor embedded camera to sense the occurrence of the animaland capture images. Since the sensor is connected to a single camera, it enables the capturing of images only in a certain area with no flexible angle. The sensor forces the camera to wake up to capture the images. The issue with this equipment is that the camera takes too long to wake up as a result the chances of missing the capture of the animal/ bird are high.

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Knowing that RFID system can use a single tag to manage multiple sensors, the flexibility of the equipment can be improved. In 2015, Salmerón et al. successfully demonstrated that an RFID tag could use more than one sensor, which includes temperature sensor, force sensor and opening detector (Fernández-Salmerón, et al., 2015). Rather than making the sensor flexible, the camera itself can be made flexible. Using this, we can have a more accurate observation and better spotting of the targeted species. The implementation will be shown later in this paper.

6. Method Proposed

The use of a camera with sensor enables automation, eliminates manual labor, and increases the chances of capturing rare images when the animal/ bird occurs. But this equipment has certain aspects that can be improved and developed for making better wildlife equipment. For the betterment of the existing equipment, *Wildlife Spotting Robots,* this paper proposes *Smart Observation System*. The proposed system overcomes the limitations of the existing system, like waking up the camera and simultaneously capturing images from different angles as soon as the animal/ bird occurs in the observation area.

6.1 Design

There are three major components to this observational system: sensor embedded tags, camera, and the database. This application uses MYSQL database for registering the cameras, sensor embedded tags, and the reader. The scenario proposed is to have a definite observation area. The observation area will be broken down into two layers: the inner area and the outer area; illustration can be seen in Figure 1.

All the sensor tags in the outer area will have the role to notify the system if there is an occurrence of an animal / bird entering the observation area. Based on the notification, the system will wake up the nearest available camera.Whereas, the sensor tags in the inner area are responsible for notifying the system if there is an occurrence of an animal/ bird inside the image-capturing area. Therefore, the system can activate the nearest camera to capture the image of the animal/ bird. The RFID readers will be located optimally near the tags so it can receive the signals from the tags around it.

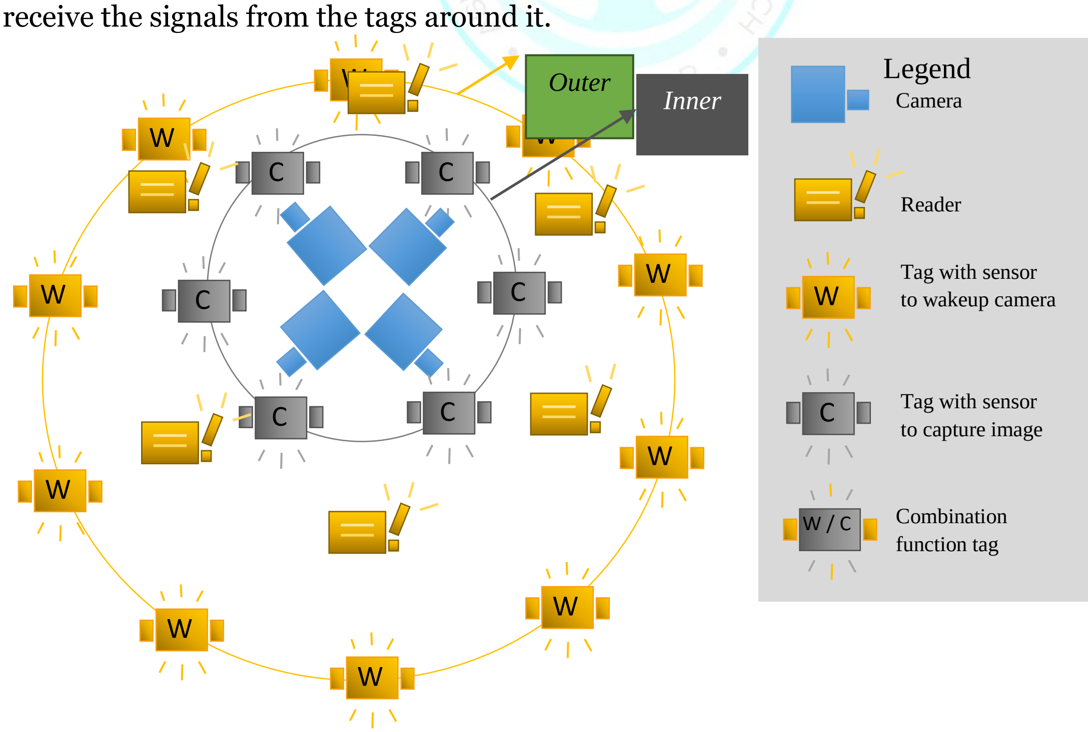

Figure 1: Design of the proposed system

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For further development and more complex scenario, a more optimized scenario can be achieved as shown in Figure 2.

In a more complex scenario, an inner sensor tag can have a dual function: waking up the camera and capturing at the same time, but for different cameras. For example, inner tag-1 can be a capture tag for camera-1 and be a wakeup tag for camera-2. Assuming that camera-1 and camera-2 are close to each other, there is a high possibility that both cameras might have a chance to capture the occurrence of the animal/ bird.

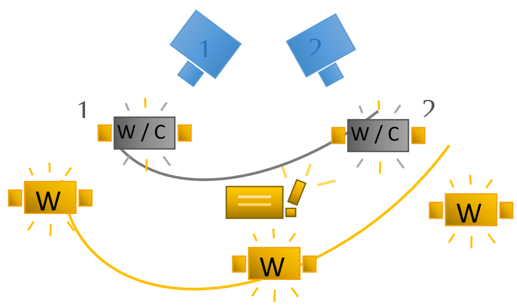

Figure 2: More complex scenario

In the system, the cameras are designed to be put to sleep after being idle for some time (not receiving any command from either wakeup or capture tag). Therefore, it is expected that the sleep mode will save power.

2.1 DATABASE

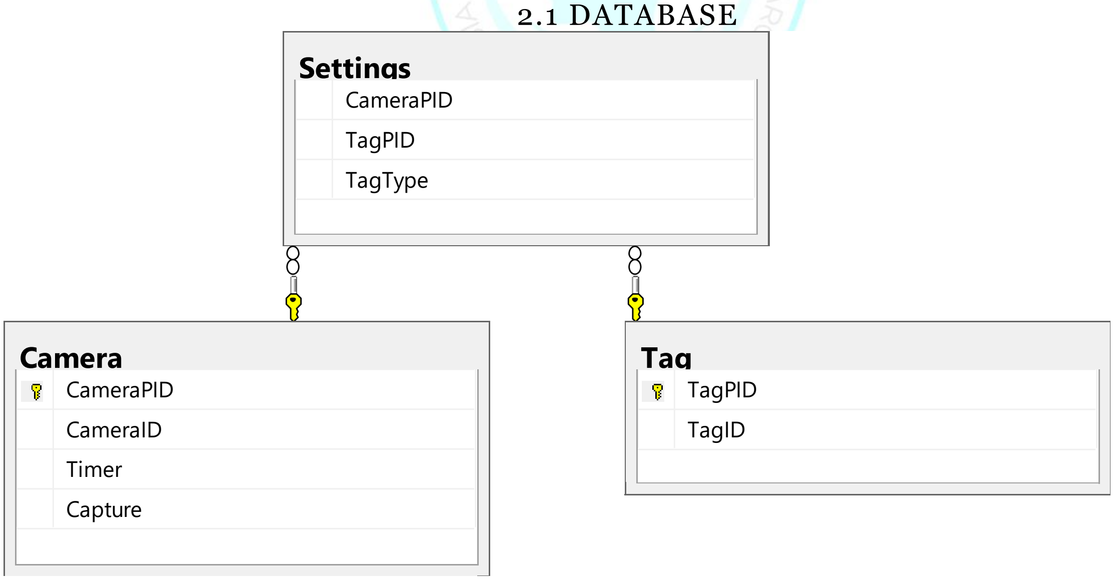

Figure 3: View of the Database

Figure 3 represents the Database for registering the cameras and the tags. The specifications for the Database (Figure 3.) are shown in Table 1, Table 2, and Table 3.

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Table 1. Database Specifications for Camera

Camera Table		
Field	Type	Desc
CameraPID	Integer	Increment ID - primary key for camera
CameraID	Varchar 50	Camera ID that is supplied from the application (from the detected connected camera)
Timer	Integer	Timer in second, to determine idle time until the camera set to sleep
Capture	Integer	Number of capture for every time capture type tag is sending signal

Table 2. Database Specifications for Tag

Tag Table		
Field	Type	Description
TagPID	Integer	Increment ID - primary key for tag
TagID	Varchar 50	Tag ID that is supplied from the application (from input or tag reading)

Table 3. Database specifications for Settings

Settings Table		
Field	Type	Description
CameraPID	Integer	Foreign key to Camera table
TagPID	Integer	Foreign key to Tag table
TagType	Bit	Type of tag assign to the camera (0:wakeup or 1:capture)

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6.2 Implementation and Testing Menu

Figure 4 is the main menu of the application. This screen includes six buttons to navigate to five screens and to close the application.

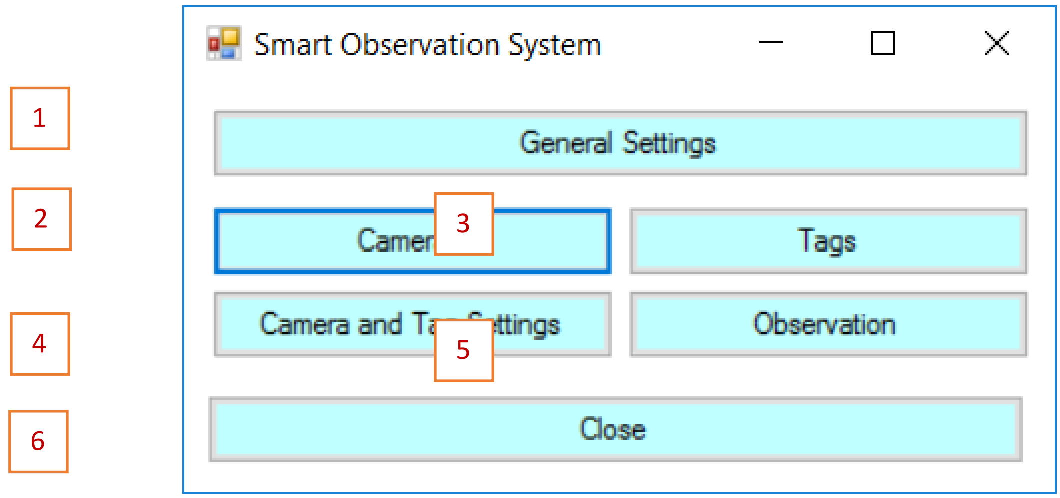

Figure 4: Menu Screen

1. *General Setting Button*: Button to navigate to "General Settings" screen.
2. *Cameras Button*: Button to navigate to "Cameras" screen.
3. *Tags Button*: Button to navigate to "Tags" screen.
4. *Camera and Tag Settings Button*: Button to navigate to "Camera and Tag Settings" screen.
5. *Observation Button*: Button to navigate to "Observation" screen.
6. *Close Button*: Button to close the application.

6. 3 General Settings

The general settings screen is the screen to set the application settings. The settings include:

- *Database settings*:
  - Database Server
  - Database Name
  - Security Type
  - Username
  - Password
- *RFID Reader Port*: Specified connected communication port used by the RFID reader
- *Picture Directory*: Specified directory to save all the images from observation activity

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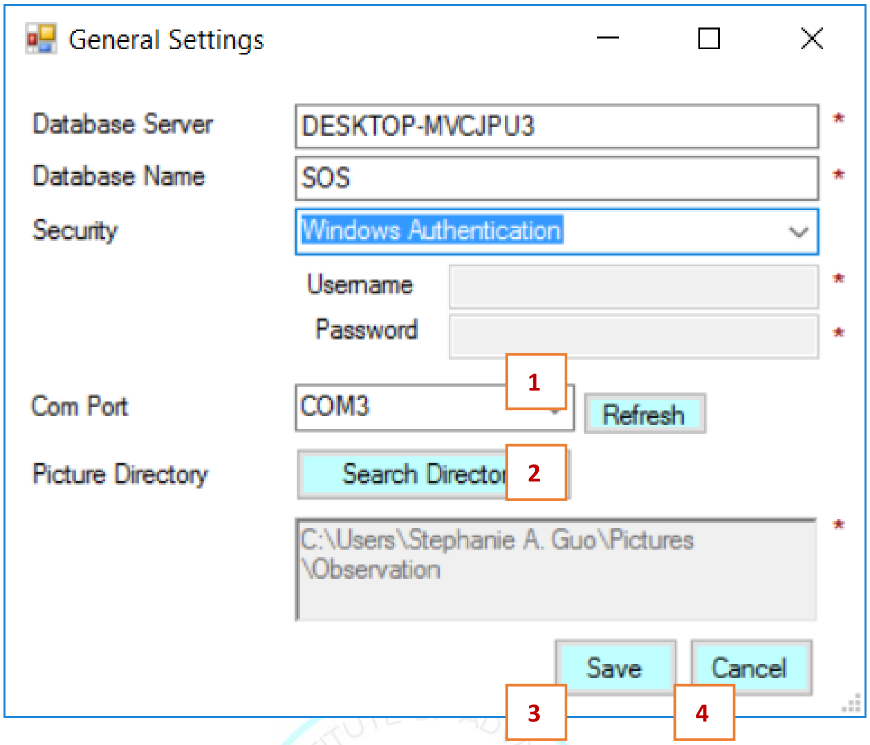

Figure 5: General Settings Screen

1. *Refresh button*: to recheck all connected communication port and show it to the list box. This button is useful in case the RFID reader communication port is just installed or plugged after this screen has been opened.
2. *Search Directory button*: to open windows to search for local directory.
3. *Save button*: to save all the settings in the screen.
4. *Cancel button*: to go back to the Menu screen without saving the changes of the settings.

6.4 Cameras

The camera screen is the screen used for registering the camera. Any webcam attached to the PC or Laptop being used can be registered in this screen. The application will detect any connected or embedded camera and show them in the list box. The screen will show the camera's information, such as:

- Camera name
- Timer
- No. of capture
- Register status
- Connected status

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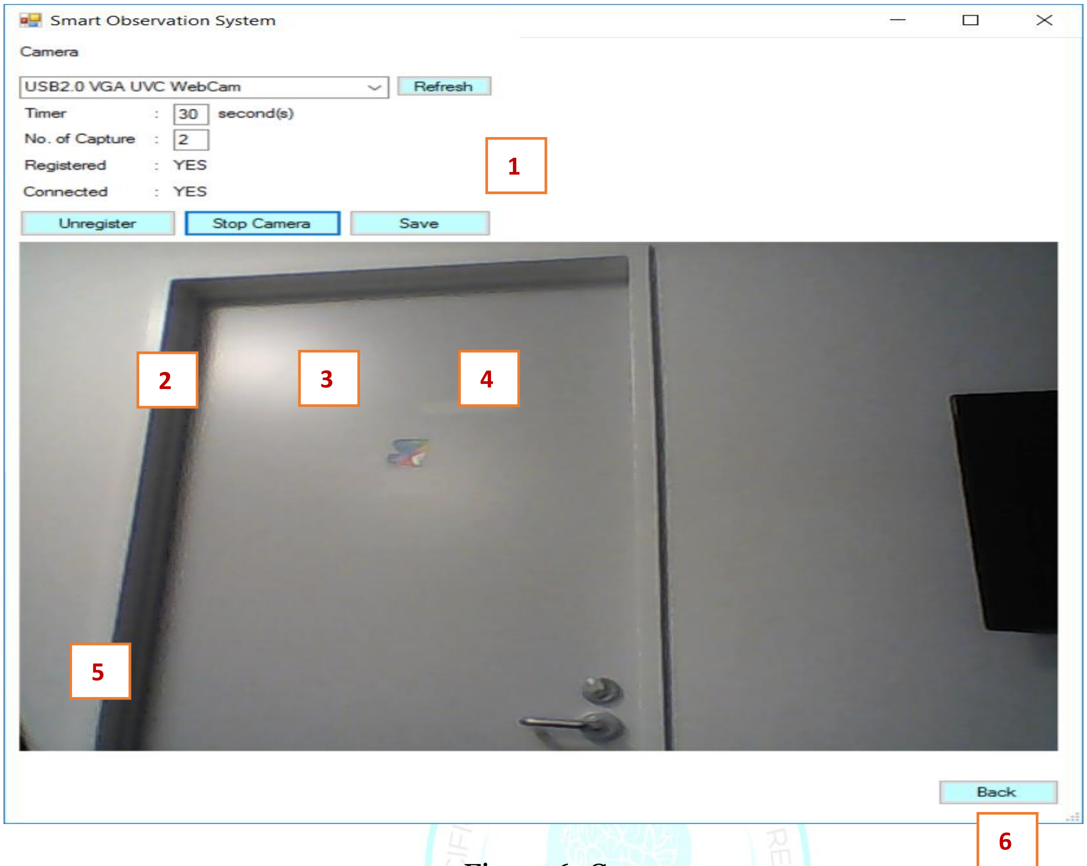

Figure 6: Cameras screen

1. *Refresh camera button*: to refresh the camera list (in case there are new cameras attached after this screen has been opened).
2. *Unregister / Register camera button*: to register a camera to the database. The text and function will change depending on the current register status of the selected camera.
3. *Test / Stop camera button*: to test or to stop testing the camera. If it is for testing the camera then the image of the camera will be rendered in the picture box.
4. *Save camera setting button*: to save any changes of timer and number of capture from the registered camera
5. *Camera picture box*: to render the image from the selected camera.
6. *Back button*: to go back to the Menu screen. Any open camera will be closed before closing the screen.

6.5 Tags

The tags screen is used to register tag to or unregister tag from the database.
In the register section, the user can type the tag ID or trigger the tag. For triggering the tag, the user should first open the RFID reader port so the application can reface the tag ID from the reader.

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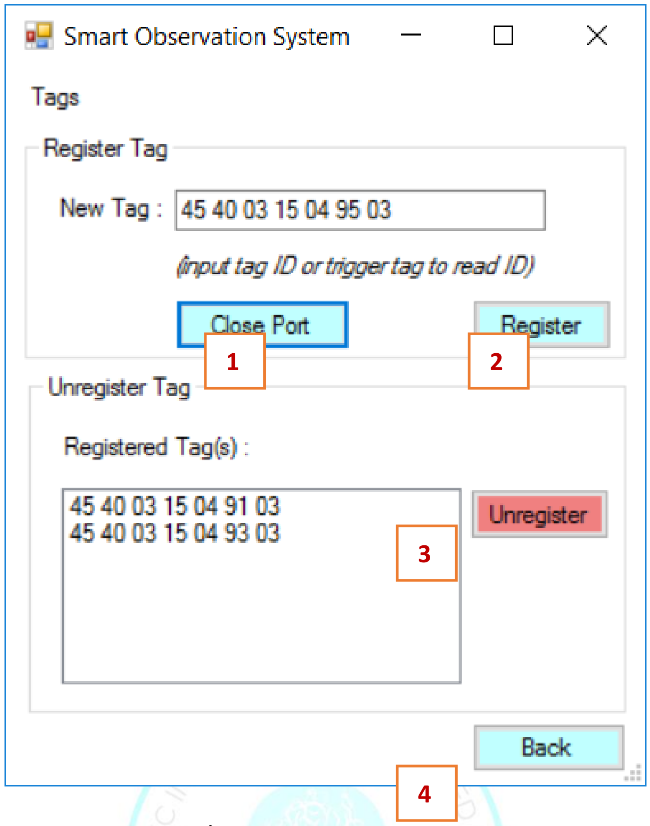

Figure 7: Tags screen

1. *Open / Close Port button*: to open or close the RFID reader communication port.
2. *Register tag button*: to register the tag ID in the textbox of the database. If the ID has been registered, then this action will pop up a warning saying that the ID has been registered.
3. *Unregister tag button*: to remove the selected tag ID in the list box from the database.
4. *Back button*: to go back to the Menu screen. The communation to the RFID reader will be closed before closing the screen.

6.6 Camera and Tag Settings

The camera and tag settings screen is used for registering the relation between the camera and the tag. One tag can be associated with multiple cameras. However, a tag for a camera can only have one relation of either being a wake-up tag or being a capture tag.

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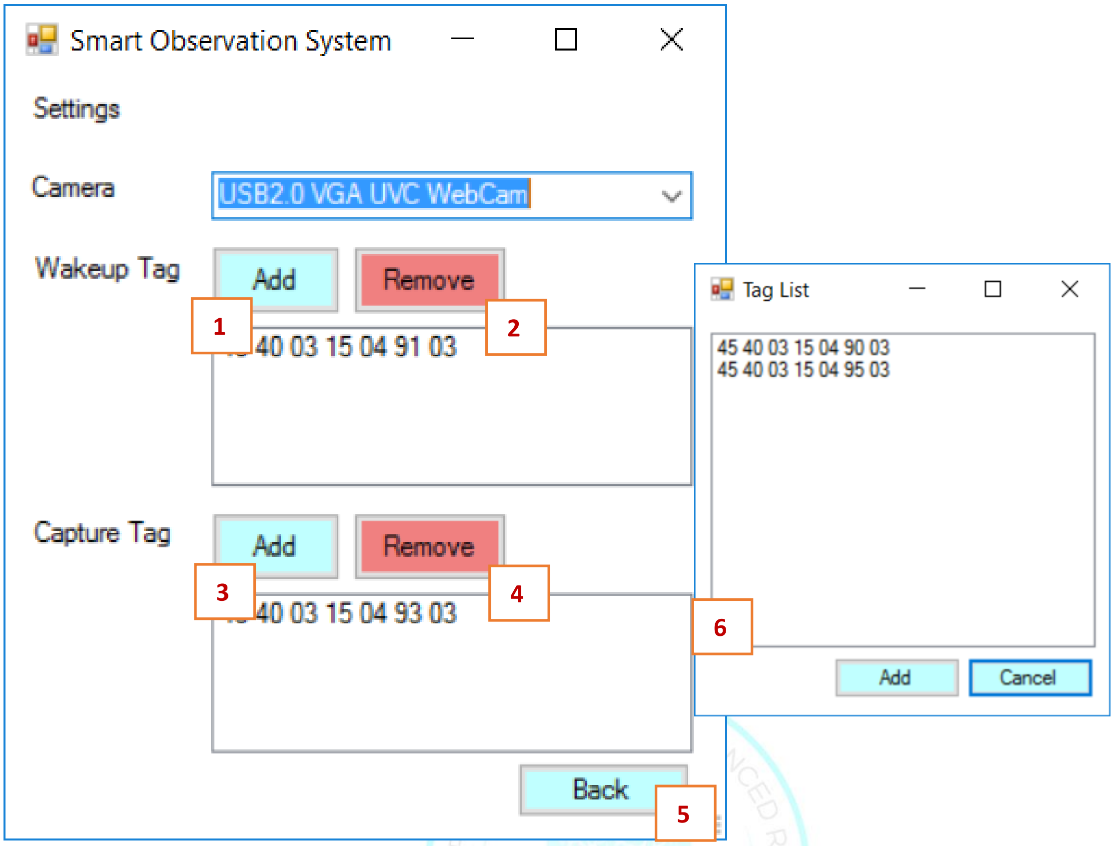

Figure 8: Settings screen

1. *Add wakeup tag button*: to relate new tag(s) as wakeup tag to the selected camera. The tag list windows will be presented.
2. *Remove wakeup tag button*: to delete wakeup relation between selected camera and tag.
3. *Add capture tag button*: to relate new tag(s) as capture tag to the selected camera. The tag list windows will be presented.
4. *Remove capture tag button*: to delete capture relation between the selected camera and tag.
5. *Back button*: to go back to the Menu screen.
6. *Tag list window*: to select which tag will be associated with the selected camera. This window will only show the list of tags that have not been associated with the selected camera.

6.7 Observation

The observation screen is used for the main activity of the application, which is observing. Once the screen is opened then the connection to the RFID reader is established so the application can receive the information every time the reader is detecting any signal from the tag. The screen will show picture box(s) depending on the number of registered cameras regardless of them being connected or not to the PC or Laptop being used.

The process of observation:

1. The RFID reader detects the signal and informs the application.
2. The application will then receive the Tag ID and check the database to see which camera is associated with the detected tag.
3. If the tag type is a wakeup tag then the application will activate the camera, render the image in the screen, and set a timer to put the camera to sleep after being idle for a certain amount of

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time. The time will always reset every time the application detects any signal from tag(s) that are associated with the camera.

4. If the tag type is capture then the application will get the image captured by the camera and save it to the picture directory that has been specified in the General Settings screen. However, if the camera is asleep then the application will only wake up the camera.
5. When the timer is firing, then the camera will be put to sleep mode to save power when there is no detection from the tag.

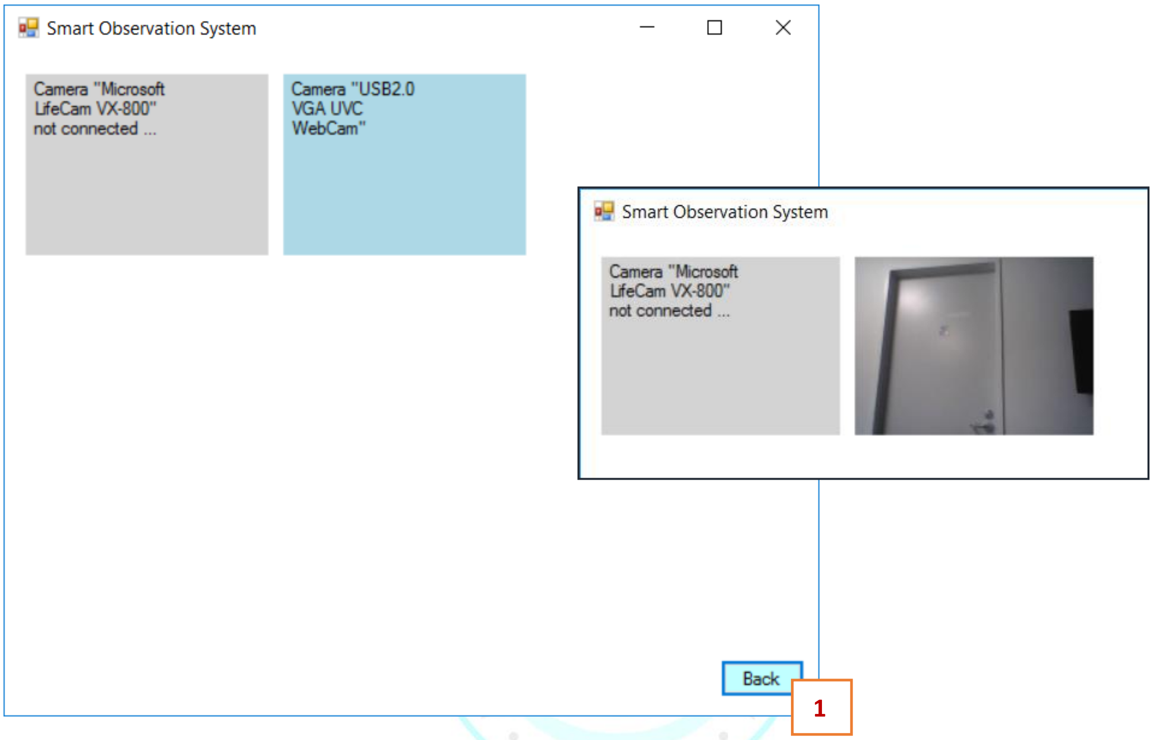

Figure 9: Observation screen

Note 1 *is the Back button*: to go back to the Menu screen. It closes all the cameras and disconnecting the communication with the RFID reader. This action is performed before this screen is closed.

6.8 Limitations

The application is developed as a prototype only and its purpose is to demonstrate the idea of the new Smart Observation System using RFID technology in a small-scale scenario, therefore, the application has some limitations. The application is not sufficient enough to be implemented in the real life wildlife observation because some limitations such as: the camera used is only web camera, limited variant of the sensor in the RFID tag, captures images only; no video recording.

In the proposed application, Smart Observation System, changing the specification of the camera would affect the application. For instance, if you change it to a specific observation camera and use some other reader or tag other than the one being used by this application then you have to adjust the codes for reading the camera ID.

The variance of sensor embedded tags used in the prototype is only of one kind, which is the motion sensor tag. In real life observation, more variance of sensor will enhance the accuracy

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and effectiveness of the observation. However, to do so the application needs an adjustment to be able to retrieve the ID of various types of tags.

The prototype also has only one RFID active reader and four motion sensor embedded tags. This means the application is not tested to retrieve signals from a massive number of tags; and should be enhanced to communicate with multiple RFID readers. Talking about the operating systems it works with, it does not work with MAC OS. This application currently works with Windows OS 7, 8, and 10; it still needs to be tested with operating systems like Linux, UNIX, etc.

Conclusion

There is enough evidence for the current RFID technology that can benefit the wildlife observation activity. The integration of RFID with wireless sensors provides benefits like expandable equipment, flexible implementation of various sensors, and a higher chance of spotting rare species. This application accomplished its goal of waking up the camera when a motion is sensed and capturing images from various angles and storing them in the database. Although, one part of the objective, to video record, couldn't be implemented due to time limitations.

Future Works

While designing and implementing this project, we realized that there are several things that could have improved this system if we had more time and a larger budget; one of which is enabling video recording along with image processing. The team has mentioned a list of recommendations in this section for future projects, without considering financial limitations. This project is just a prototype for creating the application to sense presence of any animal/ bird in the observation area and to capture it. This prototype uses only motion sensors for this purpose and can be further developed for various other sensors like infrared sensors, sound sensors, temperature sensors, touch sensors, and so on.

Since this application is just a prototype with one reader and 4 sensors embedded in active RFID tags, it only works in a limited range (without antenna: 1m, with antenna: approximately: 15m); which can be later developed for a wider range. The read range doesn't affect the working of the application in any way. Also, if we can connect this application with a panning camera, the number of images captured can be maximized from different angles. For example, when the sensor detects the presence of an animal, the system can trigger the cameras that are closest to the animal and images can be captured from different angles.

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