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System for Monitoring Marine Turtles Using Unstructured Supplementary Service Data

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Abstract**—**The conservation of marine biodiversity keeps ecosystems in balance and ensures the sustainable use of resources. In this context, technological resources have been used for monitoring marine species to allow biologists to obtain data in real-time. There are different mobile applications developed for data collection for monitoring purposes, but these systems are designed to be utilized only on third-generation (3G) phones or smartphones with Internet access and in rural parts of the developing countries, Internet services and smartphones are scarce. Thus, the objective of this work is to develop a system to monitor marine turtles using Unstructured Supplementary Service Data (USSD), which users can access through basic mobile phones. The system aims to improve the data collection mechanism and enhance the effectiveness of current systems in monitoring sea turtles using any type of mobile device without Internet access. The system will be able to report information related to the biological activities of marine turtles. Also, it will be used as a platform to assist marine conservation entities to receive reports of illegal sales of sea turtles. The system can also be utilized as an educational tool for communities, providing knowledge and allowing the inclusion of communities in the process of monitoring marine turtles. Therefore, this work may contribute with information to decision-making and implementation of contingency plans for marine conservation programs.

Keywords**—**GSM, marine biology, marine turtles, USSD.

I. Introduction

CURRENTLY, efforts are being made to protect endangered species, such as marine turtles because their population have declined dramatically due to human behavior and climate change [1]. Carter et al. [2] and Valdés et al. [3] have demonstrated that photo identification is a reliable system for collecting and identifying information about distinctive morphological characteristics of individual animals. These systems can be used to obtain information about species' life histories, behavior, populations, and survival. A few mobile applications have been developed, such as WhaleReport [4], in order to involve more communities in the monitoring process and to enhance data collection. These mobile applications were designed to be utilized only on 3G phones or smartphones with Internet access. The main problem is that communities living in rural areas are not financially prepared to acquire smartphones [5]-[7]. Also, these applications cannot be used in locations with limited and intermittent Internet services and the high cost of mobile data is an issue for these communities [8]. So, it is necessary to develop mobile applications using affordable technologies that allow reliable and secure communication in areas with limited Internet access. As a result, more data will be collected to create accurate predictive models to support decision-making and to implement contingency plans for marine conservation programs.

Weld et al. [9] demonstrated that majority of the people in rural areas use basic mobile phones that can only use second-generation (2G) services, such as Short Message Service (SMS) and USSD. Date et al. [10] and Wikedzi et al. [11] have shown that USSD technology, unlike SMS, provides a real-time and interactive communication between the user and the service provider. Also, the use of USSD for data collection allows for immediate data validation during the session flow [12].

In the literature, there are several examples of the application of USSD, which entails different fields. For example, in healthcare, a telemonitoring system to Home-based care through USSD was developed, and in the banking sector, customers can transfer money using systems developed by USSD protocol [13], [14]. As a monitoring tool, few mobile applications have been created based on USSD. For instance, Ochoa et al. [15] proposed a system based on USSD to optimize the geolocated data collection of suspected or confirmed occurrences of diseases to identify potential areas of epidemiological risk. The public health entities visualized the data collected using Geographic Information System (GIS) to help with analysis, monitoring and decision-making related to this field. They found that communities play a key role in the process of epidemiological surveillance because they are not only involved in identifying health issues but also in recommending constructive solutions to support health institutions. Srinivasa et al. [16] proposed a prototype for weather monitoring application using the ParaSense technology and Wireless Sensor Network (WSN). They developed a generic Application Programming Interface (API) that can be integrated with any user-specific application, providing data in a structured and standard form on a cloud layer. On top of that, to ensure the inclusion of rural communities they developed an embedded module that can be accessed through USSD to check the weather in that particular location at a defined time. They argued that their approach can be highly scalable and provides a solution to the masses. Hajdul et al. [17] demonstrated in their conceptual framework of the T-Traco system, Global logistics tracking and tracing in fleet management, that using USSD communication channel outperformed the current systems using General Packet Radio Service (GPRS) and SMS, in terms of reliability and price.

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They concluded that when the roaming service, under GPRS, is activated there are more fees. In cases where errors occur companies use a secondary connection using SMS, which is more expensive than the USSD, and still there is no guarantee when the SMS will reach its recipient. Another important aspect is the load of a network. In GPRS communication each session requires a separate radio band, while USSD protocol is always available when a mobile device logs on to the Global System for Mobile communications (GSM), because USSD remains in the control channel of GSM, so it is always available when a mobile device is within a cellular network. The SEMA app was developed to help water users in villages and district water engineers to monitor the functional status of well-known rural water points [18]. The application helped to reduce the downtime for water point repairs as it facilitated surfacing of the downtime problems per water point in the rural areas. It also helped to reduce the bureaucracies involved in data collection and reporting of water services information.

In summary, these studies highlight that the use of USSD for applications is well suited to people living in rural areas and can be deployed inexpensively. Even metropolitan areas have been deploying applications using USSD due to its reliability, low cost and easy user-friendly interface [17]. Importantly, [15] illustrated that by using this technology more data are collected because it increases the geographical area covered. Also, for research where communities play a key role in the monitoring process, [18] demonstrated that better results are seen when the communities are engaged to solve their own issues. However, to the best of our knowledge, there are few results in the literature regarding the impact of applying USSD technology to enhance data collection and monitoring process of endangered species, specifically marine turtles. Therefore, the objective of this work is to develop a system based on USSD protocol to be used for monitoring marine turtle species in locations where internet access is scarce. This system will allow marine conservation entities and biologists to collect more data because the system can be accessed using basic mobile phones. According to Weld et al. [9] basic mobile phones, unlike smartphones, are more used in rural areas. Consequently, more communities will be involved to protect marine turtles not only in collecting data but also in reporting of illegal sales and mortality of the species.

II. USSD

One of the key goals of this work is to involve the majority of users in the monitoring process of marine turtles, which means developing a platform using affordable technology that covers a large geographical area. USSD is used in this project due to its accessibility in areas with limited and intermittent internet services and its increased use in developing countries even where well-known technology such as GPRS, SMS, or Interactive Voice Response (IVR) are available [17]. USSD is a protocol available on the GSM network that allows the creation of a simple, text-based interface [9]. USSD technology is a session-based protocol that provides real-time communication between the user and the application provider. The session is provided until the user closes the connection or until the session times-out. Each exchanged message, between the service provider and the customer, can have a maximum of 182 alphanumeric characters. It is platform independent, available in multiple regional languages and does not require any software download. Fig. 1 shows the scheme that allows a user or subscriber to submit information regarding the marine turtles. The communication starts when a user initiates dialling a service code provided by the mobile network operator (MNO), for example, *777#. This request message is sent through GSM network to the USSD Gateway. The USSD Gateway is responsible for receiving the request and identifying which application has to be accessed in order to forward the request to it establishing a session. The application selected, in this case, it will be the system for monitor marine turtles provided by conservation marine entity, will return the initial menu to the USSD Gateway and from the USSD gateway back to the user. From this point, a USSD dialogue will start between a basic mobile device and USSD application. In [19] and [15] it is possible to see detailed information about USSD architecture and its components. The major obstacle to implement third-party USSD application is restricted access due to control by the MNO [9]. Fortunately, most of the countries, the MNO allows the deployment of applications for conservation purposes, and for other countries, implementing a USSD service requires negotiations with MNOs [9]. Also, before applying USSD architecture, it is important not only to look at its benefits but to understand its security issues and threats [19], [20]. For the proposed system, the standard security mechanism used by the USSD protocol is enough to guarantee safe delivery of the information.

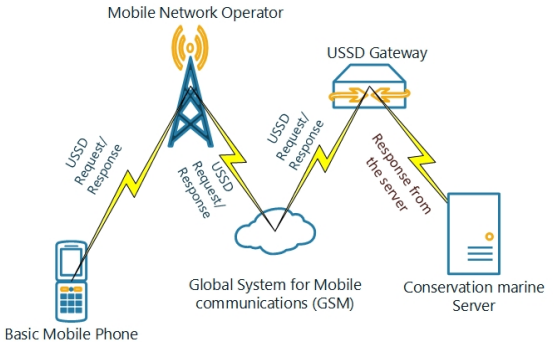

Fig. 1 USSD architecture using GSM for monitor marine system

III. Proposed Model

The system will be divided into two different modules, data collection, and data pre-processing and visualization. The data will be collected through a USSD application developed using USSDHttp libraries, and then it will be recorded into a database created using MySQL [12]. The application will be accessed by dialling a short code, for example, *777#, that will be defined by the MNO, which brings up the main menu. The system will be able to collect information related to the biological activities of marine turtles, such as nesting sites, hatching of new offspring, and marine turtle activities. Also, because their populations have declined dramatically due to

human behaviour and climate change, the system will be used as a platform to assist marine conservation entities to receive reports related to illegal sales and mortality of sea turtles. With this system, marine conservation entities will be able to make real-time decisions in order to improve the conservation of this species. Location information will be automatically provided by the MNO, allowing for site-specific decision-making to enhance resource sustainability and conservation [21]. Alternatively, the users themselves could provide a province name, district/city name and a brief visual description of the location (182 alphanumeric characters) in cases where MNOs fail to obtain the location information or reports are made at a different location than observations.

Before applying the data to a decision-making, it is important to pre-process the raw data to eliminate nonsensical data before passing it to decision makers [22]. The pre-processing will be executed by a conservation marine specialist using program R. Biological activities of marine turtles, illegal sales and mortality information will automatically be plotted in the Geographic Information System mapping technology (QGIS) using Python and Django Web Framework based on the geographic location collected from the users [23]. Conservation entities and biologists could then visualize and analyse the data for further implementation of contingency plans for marine conservation programs (Fig. 2). Therefore, with the knowledge acquired, marine conservation could make plans for specific areas according to their need. For instance, in areas with high levels of mortality due to human behaviour, communities should be given workshops about why marine turtles are important to the marine ecosystem to mitigate the mortality issues.

To assist people without prior knowledge about marine turtle species, the system will include an automatic model to identify species using shell characteristics [24]. The model uses a C4.5 Decision Tree algorithm to identify species using scute patterns from sea turtle identification keys. This model has demonstrated high accuracy and allows for standardized identification from many different sources. Communities will be educated about the use of the model decreasing the need for turtle experts in these communities (Fig. 3).

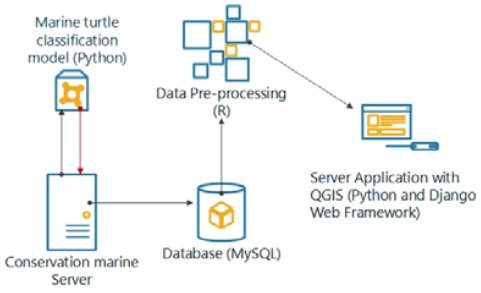

Fig. 2 Proposed model

Fig. 3 Decision tree for classification of marine turtle species using scutes patterns [24]

A. Examples of Use Sessions

It is important to mention that the aim of this work is to develop a non-intrusive system for collecting information about marine turtles. The system will allow the biologists to track in inexpensively manner marine turtles using their tag numbers. However, users are forbidden to have a physical contact because it can cause stress to the animals [3].

The main menu allows users to submit information related

to turtles and their biological activities, send reports of illegal sales of sea turtles and read about the instructions on how to use the application. Upon selecting the option in the main menu, the user is presented with a sub-menu. After making a selection, the user is prompted to enter multiple possible results, then the user is given a few menus where they are prompted to select from the possibilities. Figs. 4-6 show different interaction through use sections to collect information and to make an automatic perdition about the marine turtle species.

IV. Conclusion

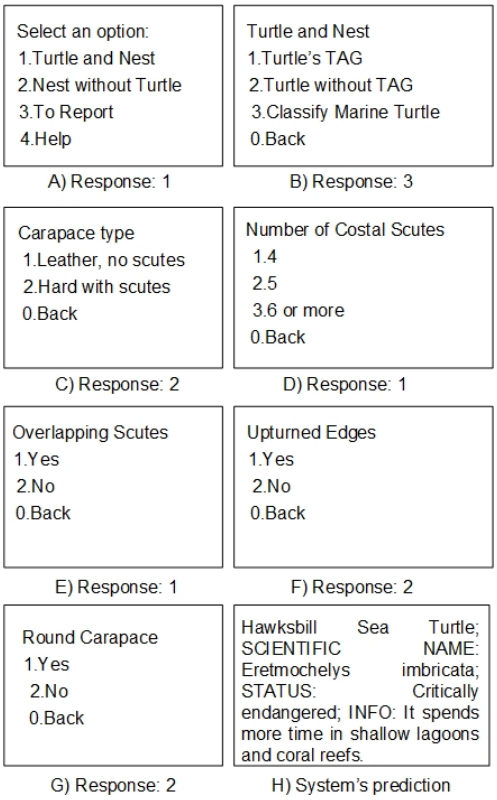

Fig. 4 An example of classification of a marine turtle species use sessions. Screens A-H show the steps to classify marine turtles using an automatic Identification Key model

Mobile applications based on USSD protocol has had a great impact on delivering knowledge and providing services to the society living in rural areas in developing countries. Using the proposed platform, more data can be collected to enhance research about marine turtles and more communities living on the coastline can be involved in marine turtle conservation. This technology must be combined with educational programs to improve knowledge about marine turtles and the importance of conservation. Currently, data are only available for local analysis, limiting the scalability of the project. The proposed system can fill this data gap and allow large-scale conservation methods to be combined with site-specific conservation efforts. Thus, highly accurate predictive models can be created to improve decision-making in the implementation of regional and international conservation programs.

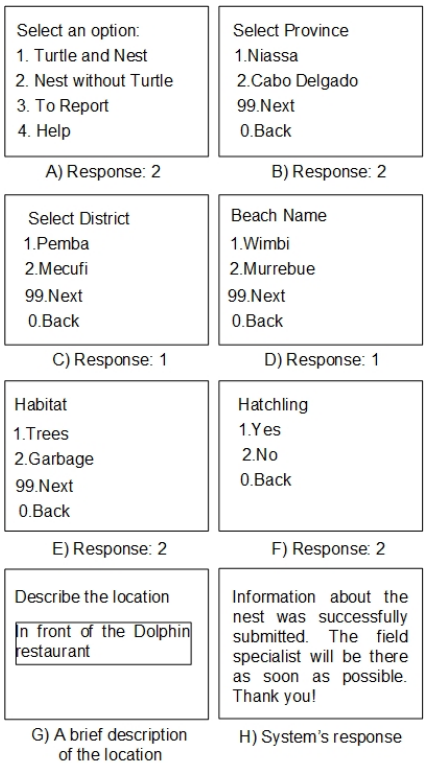

Fig. 5 An example of the nest use sessions. Screens A-H show the steps to submit information about found nest

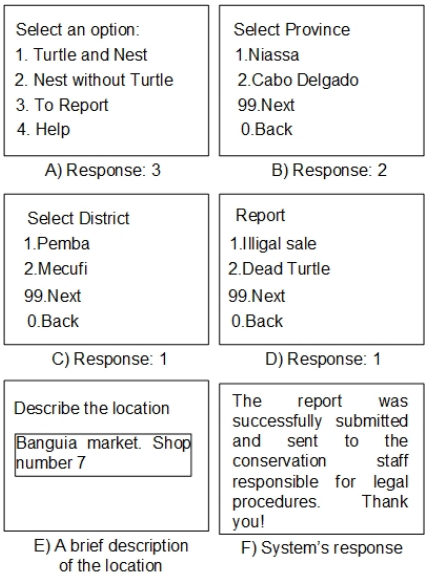

Fig. 6 An example of report use sessions. Screens A-F show the steps to make a report of illegal sale of marine turtles

Future work should focus on the development of additional features for the system, such as a cloud layer where data about the marine turtles are shared in real-time and user-friendly

applications to access the results of analyses. The system could also be adapted to other areas, such as elephant conservation.

REFERENCES

[1] G. Leroux, B. Rakotonirina, S. Ciccione, and S. Hawawini, "First report of Chelonia mydas affected by cutaneous fibropapillomatis on the West coast of Madagascar," *J. Exp. Mar. Bio. Ecol.*, no. 11, pp. 13–17, 2010.

[2] S. Carter, I. Bell, J. Miller, and P. Gash, "Automated marine turtle photograph identification using artificial neural networks, with application to green turtles," *J. Exp. Mar. Bio. Ecol.*, vol. 452, pp. 105–110, 2013.

[3] Y. A. Valdés, J. A. Ricardo, F. B. Trelles, and O. Espada, "First Assay of photo-identification in marine turtles' nesting population," *Rev. Investig. Mar.*, vol. 34, pp. 43–51, 2014.

[4] B. C. C. S. N. Ocean wise, "WhaleReport." Ocean Wise Conservation Association, Vancouver, 2018.

[5] S. Wyche, T. R. Dillahunt, N. Simiyu, and S. Alaka, "'If God Gives Me The Chance I Will Design my Own Phone': Exploring Mobile Phone Repair and Postcolonial Approaches to Design in Rural Kenya," *UbiComp '15, Sept. 07-11, Osaka, Japan*, 2015.

[6] S. P. Wyche and L. L. Murphy, "Powering the cellphone revolution: findings from mobile phone charging trials in off-grid Kenya," in *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems - CHI '13*, 2013, p. 1959.

[7] S. I. Ahmed, S. Guha, M. R. Rifat, F. H. Shezan, and N. Dell, "Privacy in Repair: An Analysis of the Privacy Challenges Surrounding Broken Digital Artifacts in Bangladesh," in *Proceedings of the Eighth International Conference on Information and Communication Technologies and Development - ICTD '16*, 2016, pp. 1–10.

[8] S. P. Wyche and L. L. Murphy, "Dead China-Make: Phones off the Grid: Investigating and Designing for Mobile Phone Use in Rural Africa Design and Human Factors," *DIS 2012,* no. ACM 978-1-4503-1210-3/12/06, 2012.

[9] G. Weld *et al.*, "eKichabi: Information Access through Basic Mobile Phones in Rural Tanzania," 2017.

[10] S. Date, Suraj., Naghmare, Avinash., Sharma, Nitin., Chavan, "USSD Based Universal Application," *Int. J. Sci. Res. Comput. Sci. Eng. Inf. Technol.*, vol. 2, no. 2, pp. 692–694, 2017.

[11] T. Wikedzi, R. Sinde, and D. McIntyre, "System Analysis and Design for integrated sponsored SMS/USSD Based M-Services (A case study of Maternal Health M-Service in Tanzania)," *arXiv Prepr. arXiv1408.1201*, vol. 12, no. 7, pp. 1–11, 2014.

[12] T. Perrier, B. DeRenzi, and R. Anderson, "USSD: The Third Universal App," *Proc. 2015 Annu. Symp. Comput. Dev. - DEV '15*, pp. 13–21, 2015.

[13] B. Wouters, J. Barjis, and G. Maponya, "Supporting Home Based Health Care in South African Rural Communities Using USSD Technology Supporting home based health care in South African rural communities using USSD technology," *Amcis 2009*, no. May 2014, pp. 1–9, 2009.

[14] R. Cs, "Digital payments system and rural India : A review of transaction to cashless economy," vol. 3, no. 5, pp. 169–173, 2017.

[15] S. Ochoa, J. Talavera, and J. Paciello, "Applying a Geospatial Visualization Based on USSD Messages to Real Time Identification of Epidemiological Risk Areas in Developing Countries: A Case of Study of Paraguay," *Stud. Health Technol. Inform.*, vol. 216, pp. 396–400, 2015.

[16] K. G. Srinivasa, N. Siddiqui, and A. Kumar, "ParaSense -- A Sensor Integrated Cloud Based Internet of Things Prototype for Real Time Monitoring Applications," *2015 IEEE Reg. 10 Symp.*, pp. 53–57, 2015.

[17] M. Hajdul and A. Kawa, "Global logistics tracking and tracing in fleet management," vol. 9011, no. March, 2015.

[18] R. Lemmens, J. Lungo, Y. Georgiadou, and J. Verplanke, "Monitoring Rural Water Points in Tanzania with Mobile Phones: The Evolution of the SEMA App," *ISPRS Int. J. Geo-Information*, vol. 6, no. 10, p. 316, Oct. 2017.

[19] B. W. Nyamtiga, A. Sam, and L. S. Laizer, "Security Perspectives for USSD Versus SMS in Conducting Mobile Transactions: A Case Study of Tanzania," *Int. J. Technol. Enhanc. Emerg. Eng. Res.*, vol. 1, no. 3, 2013.

[20] K. K. Lakshmi, H. Gupta, and J. Ranjan, "USSD — Architecture analysis, security threats, issues and enhancements," in *2017 International Conference on Infocom Technologies and Unmanned Systems (Trends and Future Directions) (ICTUS)*, 2017, pp. 798–802.

[21] R. C. Bertuzzi Leonelli and J. P. Salazar Fernández, "Diseño e implementación de un servicio de localización y visualización de mapas utilizando J2ME para dispositivos móviles y herramientas de libre distribución," *Síntesis Tecnológica*, vol. 3, no. 2, pp. 39–57, 2007.

[22] L. Pina, L. Rajamanickam, and S. C. Ng, "Feature Extraction of the Carapace for marine Turtle Species Categorization," *Int. J. Sci. Eng. Technol.*, vol. 5, no. 9, pp. 425–429, 2016.

[23] T. Athan, "Quantum GIS User Guide," 2010.

[24] L. Pina, L. Rajamanickam, and S. C. Ng, "A Hybrid Model for Pattern Recognition of Marine Turtle Species," *Int. J. Sci. Eng. Technol.*, vol. 5, no. 10, pp. 491–495, 2016.