**Remote Sensor Network**

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**Abbreviation: RSNET**

**Research type: Intelligent Systems and Advanced Telecommunication (ISAT)**

1. **Brief Description:**

The potential provided by solar power combined with the dangers raised by greenhouse gas emissions leading to climate change have paved the way for the adoption of the solar technology and subsequent investments in solar installations as a less polluting power source alternative. It has been reported in [1] that if humanity could capture one tenth of one per cent of the solar energy striking the earth, the World would have access to six times as much energy as we consume in all forms today. The African continent receives an average of 6kWh of solar energy per square meter every day [2]. Yet, as currently exploited, solar power is still an untapped resource representing only a minuscule fraction of the planets power generation capacity. Solar technology infrastructures provide the potential for social and economic advances in the rural areas of the developing world which generally suffer from a lack of appropriate and reliable electrical grids. The monitoring of solar power installations is an important parameter upon which wide scale deployment of such infrastructures depends. Some of the advantages of solar installation monitoring include (1) letting businesses and home owners to get a real-time readout of their solar panels with the associated economic benefit of making the best trade-off between switching between electrical and solar supply (2) rapid problem identification and pre-emptive resilience to failure allowing qualified service technicians to quickly fix the problem (3) self-repairing of the solar system through automated software when possible. The main goal of this project is to develop a cost effective remote sensing network (RSNET) for the continuous acquisition of remote energy yields and performance measures of a network of installed solar power systems. As a new innovative solution that demonstrates a low cost mechanism using the existing mobile network infrastructure, the remote sensor system to be developed presents the following key benefits:

* Access to PV system performance from anywhere through the use of Internet.
* Reports of power output and energy production trends.
* Verification of system operation.
* Collection of data for service and maintenance planning.
* Use of least cost devices to enable replicability of the solution.

The main features of the remote sensor network include (1) solar power consumption monitoring using sensors measuring panel voltage and current capture (2) information dissemination using SMS and GPRS protocols (3) data publishing using Web services based on PHP and associated graphing tools, and 4) situation recognition (awareness and prediction) using machine learning techniques and/or statistical analysis methods.

1. **The Main Tasks:**

The last decade has experienced a wide deployment of the sensor technology in many fields. However, its deployment in the monitoring of harvested energy has been only poorly addressed by both the research and practitioner communities. Therefore, research has to be done and experimentation conducted to assess the field readiness of sensor systems in such deployments. The main tasks involved in this project are:

**Task1: Sensing and Communication.** This project will start with a survey of different sensor technologies used for monitoring solar power consumption in terms of panel voltage, current capture and solar panel environmental parameters such as temperature, humidity. Thereafter, the project will focus on the design and implementation of an experimental Test-bed where the most relevant sensors will be used and tested for field readiness. Lastly, communication between the solar power systems and a remote monitoring place will be experimented using different protocols (SMS, WiFI and GPRS) communicating between different devices: sensor motes, mobile phones, and gateways such as Raspbery pi, Alix boards, etc.

**Task2: Security and Confidentiality.**  Besides the field readiness of the solar data capturing, efficient solar management requires secured data communication to avoid data tampering of the information collected and other security issues which may annihilate the usefulness of the solar monitoring system. This project will survey different security methods to be used for lightweight data communication and build upon the most efficient to design and implement a secured solution for solar power monitoring system.

**Task3: Situation Management.** Situation awareness and prediction are two key features of a situation management that may be implemented following different techniques. These include visual representation using methods borrowed from the computer graphics field, statistical analysis and machine learning techniques taken from the artificial intelligence field. As a first step toward situation awareness, data publishing using Web services based on PHP and graphing tools will be used to recognize recurrent patterns in the massive datasets collected from the solar system. This will be complemented by the use of machine learning techniques and statistical analysis methods to find hidden patterns in the datasets resulting from the sensor readings and predict future patterns for the remote sensor network.

1. **Computer Science Content:**

Network security, Distributed systems, Machine learning techniques, Web services, Sensor networks

1. **Specific Learning Outcomes:**

* **Task 1:** Sensor programming and communication protocols.
* **Task 2:** Network security, cryptography and privacy.
* **Task 3:**
  + **Task3.1:** Web services including PHP and computer graphics.
  + **Task3.2:** Machine learning techniques and/or statistical methods for situation awareness.
  + **Task3.**3: Machine learning techniques and/or statistical methods for situation prediction.

1. **Skills Required by the students working on the project:**

* **Theory:** Statistical analysis methods, Neural networks, Bayesian Belief networks, Artificial Immune Systems, Genetic algorithms, Security protocols and encryption, web services and computer graphics.
* **Implementation:** Implementation intensive project. Security mechanisms for sensor networks at both the encryption and communication protocol levels will be designed and implemented for different devices. An intelligent situation management system capable of finding hidden patterns in the datasets collected from the solar power system will also be designed. Sensor networks will be programmed for both sensing and communication with different devices.

1. **Facilities Needed:**

* Two types of sensor kits: Zolertia Z1 and Arduino sensors
* TELIT GSM modems and/or other modems for SMS and GPRS communication.
* Xbee shields using ZigBee and WiFI will be used for real-time and opportunistic communication.
* Mobile phones will be used as end-user devices.
* Alix boards, Raspbery pi or Android tablets will be used as gateways.

1. ***Supervision:***

* Joint supervision by CS department researchers and Saaimec
* Regular meetings will be scheduled for interaction with the supervisor and co-supervisors.
* Members of the ISAT group at UCT working on similar IoT projects can be consulted.

1. **Maximum number of students**: 6

* One student for task 1
* One student for task 2
* Three students for task 3:
  + one student on web services and graphing
  + One student on situation recognition
  + One student on situation prediction

1. **Related work [3]**



**REFERENCES.**

[1] ”**Smaller, cheaper, faster: Does Moore’s law apply to solar cells?**”: http://goo.gl/qcUcm

[2] ”**Africa: Time to go solar**”: http://goo.gl/w0QXt

[3] *M. Nkoloma, M. Zennaro and A. Bagula, “***SM 2 : SOLAR MONITORING SYSTEM IN MALAWI”,** in Proceedings of the ITU Kaleidoscope 2011.

[4] N. Schelling et al, ”**SIMbaLink: Towards a Sustainable and Feasible Solar Rural Electrification System**”, in Proceedings of the International Conference on Communication Technologies and Development (ICTD) 2010.