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A Solar Powered Smart Travelling Bag With An Embedded Video/Audio Player

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Abstract— Travellers have experienced one of these three prominent occurrences, waiting time, luggage theft and excess luggage charge. Waiting time can be converted into "relaxation time" while luggage theft and excess luggage charge can be avoided. This paper proposes a smart bag that allows travellers to watch movies and listen to music on the go. This was made possible by a theatre system specially designed for the bag. A 3D trilateration technology and a GPS tracker installed in the smart bag checkmated the problem of luggage theft while an inbuilt luggage weight sensor made it possible to give travellers' a foreknowledge of the weight of their luggage to avoid the ever present possibility of being charged for excess luggage weight. The smart bag system is powered by a solar panel that allows mobile devices to be charged via dedicated ports on the smart bag.
Keywords—Smart; Bag; GPS; GSM; Satellite; Transducer; Internet of Things

I. INTRODUCTION

Waiting for a flight at an airport, bag theft and excess luggage charge have become so rampant that it sometimes has a negative psychological and emotional effect on travellers. The effect of these common travelling occurrences can be cushioned. A smart travelling bag is a very unique solution that helps to engage travellers' waiting time during journeys.

The green energy powered traveling companion is a traveling bag that restores the comfort in journeys. It simply converts waiting times at airports, train stations and other traveling cluster points to relaxation times.

This bag is an all-in-one solution for travellers. It is a solar powered bag with a power bank for charging mobile devices. It is also equipped with a GPS module that provides tracking abilities in cases of theft and a real-time weight measuring system that indicates the weight of the bag via an LCD screen attached to the handle of the bag.

The traveling companion is solar powered. A DC-DC buck converter provides regulated 5V DC output that can be used to charge mobile devices.

The US military developed a constellation of 31 medium earth orbiting satellites and trilateration (the determination of absolute or relative location points by measurement of distances, using the geometry of circles, sphere or triangles) technology that enables the acquisition of exact real-time location coordinates in latitude, longitude and time. A GPS receiver embedded in the bag collects data transmitted by these satellites and a microcontroller decodes the data collected.

An added feature is its weight-measuring ability. A load cell (a transducer which can translate pressure or force into an electrical signal) measures the weight of the bag and makes the measurement available to the user.

The weight sensor in this case is embedded in the handle of the bag; it is not a wireless application as it is in other available devices. This work has eliminated the challenge of not been able to access the weight when the mobile phone battery runs down. This is often the case during long travels. The design presented in this paper carries a weight sensor in the bag handle and a small screen on the handle automatically shows the weight of the bag.

The remaining part of this paper is organized in this manner; section two contains the review of existing literature on the subject of smart bags. Section three is a detailed expository on the methodology used to design and implement the smart bag. Section four is a brief on how the implemented system was tested. A conclusion is made and an idea for future work is given. A list of references is given at the end of the paper.

II. LITERATURE REVIEW

An electronic luggage follower that makes use of a different kind of design other than GPS maps and self-localization was explored by [1]. The smart luggage follower made use of a control system and a target following approach. The designers came up with the concept of a smart luggage follower that uses a special signal emitted from the luggage and a direction control application installed on a mobile device. The smart luggage follower also had obstacle avoidance capabilities A bag was designed to automatically follow its owner in [2] using ultrasound sensors. The bag could send distress short messages using the cellular network [3] whenever it has been tampered with and charge portable devices like laptops and phones en route. A smart bag with an inbuilt solar panel was designed and implemented by [4]. The smart bag was operated via an android application and also had the added feature of being able to verify the contents of the bag. The authors in [5] designed and implemented a smart bag that used Radio Frequency Identification [6] (RFID) technology to keep track of the contents of the bag. An RFID reader reads the tags on the items in the bag and sends the list to a microcontroller which compares the received list to an already saved list to determine if any item is missing. The smart bag is able to send an alarm in the form of a voice prompt that an item is missing. The smart bag was also equipped with a lock that can be opened only by the owner of the bag. Any attempt by anyone other than the owner to open the bag triggered the Short Message Service (SMS) alert feature [7] of the smart bag. The SMS feature enables the smart bag to send a message to the owner in the event that any unauthorized person tampers with the bag.

A researcher [8] used fixed resistor values to design a smart bag that triggers an alarm whenever any of its contents is removed. It works on the principle of a threshold voltage below which an alarm is triggered to alert the owner of the smart bag of an on-going or accomplished theft. A special contact attached to a springy platform base selects any of the available resistances. The combination of a resistance sensing circuit and a resistor in series with the sensed resistance allows the threshold voltage below which the alarm is triggered to be pre-set. A detailed report on the design of other kinds of smart bags can be found in [9] [10] [11].

To the best of our knowledge, we have not seen in available literature where a mini video screen is employed in smart bag design. This is a major addition to the smart bag design and implementation.

III. METHODOLOGY

The aim of the proposed smart bag design and implementation is to bring comfort to travellers by offering them an “in-bag” portable video player. The bag’s security is provided by an embedded GPS tracking system. The added value of weight measurement and solar power bank are provided by load and solar cells respectively. The entire system was powered by a solar Photovoltaic module and a backup Lithium-ion battery pack. Using SMS, location data can easily be retrieved, parsed and visualized on a mobile application (Google Maps).

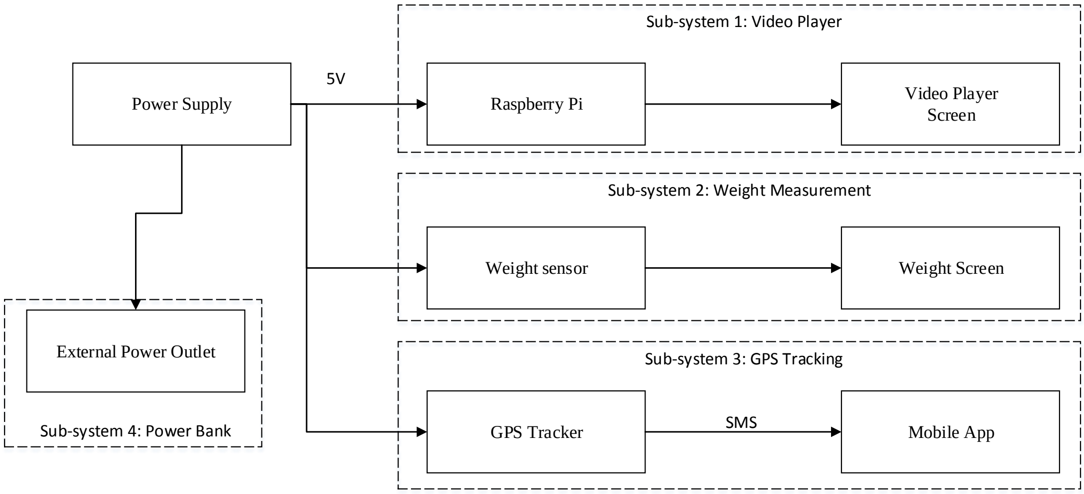

Figure 1: Representation of the overall system's block diagram

The proposed overall system has four sub-systems that perform the functions of playing videos, measuring weights, real-time tracking and power generation.

3.1. The Power Sub-system

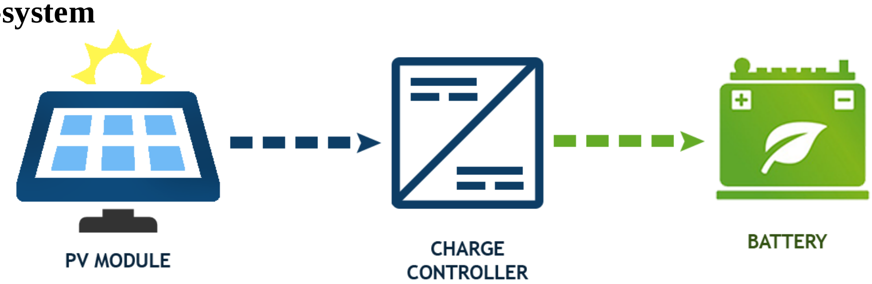

Figure 2: Pictorial Representation of the Power Sub-System

This sub-system is responsible for providing Direct Current (DC) power for the entire system and also for charging USB devices such as mobile phones, tablets, and other 5V, 1A DC appliances. The specifications for this sub-system are shown in Table 1.

Table 1: Power Supply sub-system Specifications

Input	6V DC (Output from Solar panels)
Output	5V DC
Solar Panel Ratings	6V DC, 500mA

The power supply sub-system is made up of a solar module with miniature charge controller and battery bank. The battery bank made use of rechargeable Lithium-ion cells because it offers a high Depth of Discharge (DOD) of about 80% and low self-discharge.

3.2. The Combined Photovoltaic Module

The Photo-Voltaic (PV) module which converts solar energy to electrical energy serves as the main source of power or generator of electricity for the system. It has the following ratings:

- Power = 3W ± 5%
- Open Circuit Voltage (V) = 7.2V DC

- Short Circuit Current (A) = 568mA DC
- Working Voltage = 6V DC
- Working Current = 500mA

A constant current of 500mA and a voltage of 6V were obtained by using the combined photo-voltaic module (charge controller incorporated). This provided power to charge the batteries and for the entire system. The combined photovoltaic module offers the advantage of producing a steady output voltage as a result of the inbuilt charge controller present.

3.3. The Combined Photovoltaic Module

Working voltage = 6V
Peak sunshine hours = ~1.5hrs

- Required solar Panel power = 4WH / 1.5 = 2.67W
- Working current = 2.67W / 6V = 445mA

3.4. The Relaxation Sub-system

The long waiting times at airports could be converted into moments of relaxation. The relaxation sub-system takes care of this. At the core of this is a Raspberry Pi module. The Raspberry Pi is a single board computer providing automation, and general purpose computing functionality. This micro-computer powers a 3.2” TFT resistive touch LCD screen with a resolution of 320 X 240 pixels/inch, 16bit data interface, 65K colour, 34 pin interface, LCD breakout and touch screen. Using this screen, the user has the ability to watch movies, videos and even listen to audio from this system using an earpiece. Video playing software was developed via an open source cross platform desktop application development framework using JavaScript, HTML and CSS. The user can relax while waiting to board a means of transportation with a video playable from a removable USB flash drive.

3.5. The Weight Measurement Sub-System

The weight of the travelling bag was measured using TAS606 load cell and HX711 load cell amplifier. The TAS606 has the specifications shown in Table 2.

Table2: TAS606 Load Cell Specifications

PROPERTY	SPECIFICATION
Capacity	40kg/10g, 50kg/10g (Unit: g, kg, lb, oz.)
Comprehensive error	0.05mv/v
Output sensitivity	1.0 ± 0.1
Input Resistance	1000±20Ω
Output Resistance	1000±20Ω
Insulation Resistance	≥5000MΩ
Excitation Voltage	≤10V

The HX711 has the following ratings:

- Operation Voltage: 2.7V–5V
- Operation Current: < 1.5mA
- Selectable 10SPS or 80SPS output data rate
- Simultaneous 50 and 60Hz supply rejection

The internal structure of the weight measuring device is as illustrated in Figure 3. The HX711 load cell amplifier used a two-wire interface (Clock and Data) for communication. It was connected to a micro-controller that easily read the subtle changes that occur in the load cell’s resistance. A well-structured calibration helped to take accurate weight measurements.

3.6. The Location Tracking Sub-System

The position of the travelling bag was accurately determined on-demand with the geolocation data received from the Global Navigation Satellite Systems which is a constellation of satellites in the Medium Earth Orbit. This sub-system comprises of a GPS receiver and a GSM module.

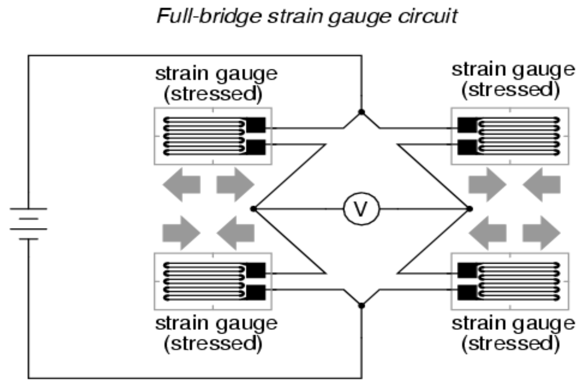

Figure VI: The Full bridge strain gauge circuit

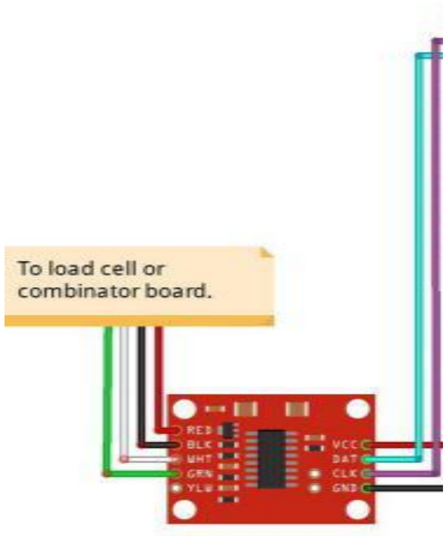

Figure 4: The Load Cell Amplifier

3.7. The GPS Receiver

The GPS receiver was based on a high sensitivity GPS microcontroller chip. It interprets signals from GPS satellites and determines the position of the GPS receiver. It possesses these features:

- A 20-channel receiver, which can process the signals of all visible GPS and WAAS satellites simultaneously.
- A Power consumption of 62 mW during continuous operation.
- A Receiver sensitivity of -159 dBm while tracking.

Table 3 shows the basic specifications of the GPS microcontroller chip.

Table 3: GPS Tracker specifications

GPS chip	SIRF3 chip
GPS sensitivity	-159dBm
GPS accuracy	5m
Time To First Fix	Cold status 45s Warm status 35s Hot status 1s

3.8. The GSM Module

The GSM module is based on the SIM800L chip. This module provides GSM functionality for the system allowing location data to be relayed to the user via the nearest cell tower. This chip has the specifications shown in Table 4.

Table 4: GSM Module Specifications

• Network	• GSM/GPRS
• Band	• 850/900/1800/1900Mhz

A phone was used as the tracking device and Google Earth was the tracking software. Figure 5 and Figure 6 show the GPS/GSM module (back and front view) and the weight sensor.

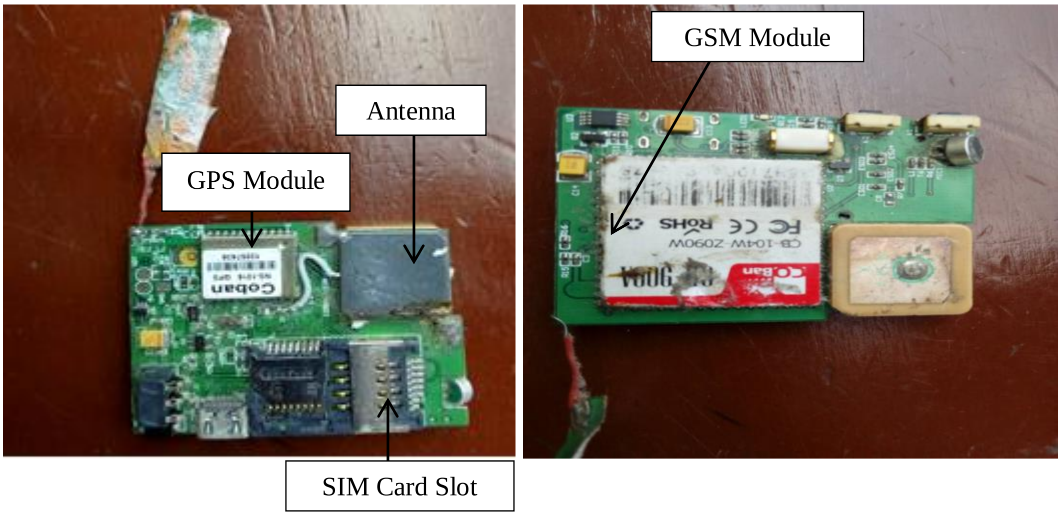

Figure 5: The Mini GPS/GSM Module (Back and Front View Respectively)

Figure 6: Picture of Smart Bag Showing the Weight Reader.

3.9. The Mobile Application

The mobile application was developed using the typescript language, Angular 2 and Ionic 2 frameworks. The flowchart in Figure 7 describes the flow of the mobile application. Figure 8 shows a screenshot of how the application works in real-time.

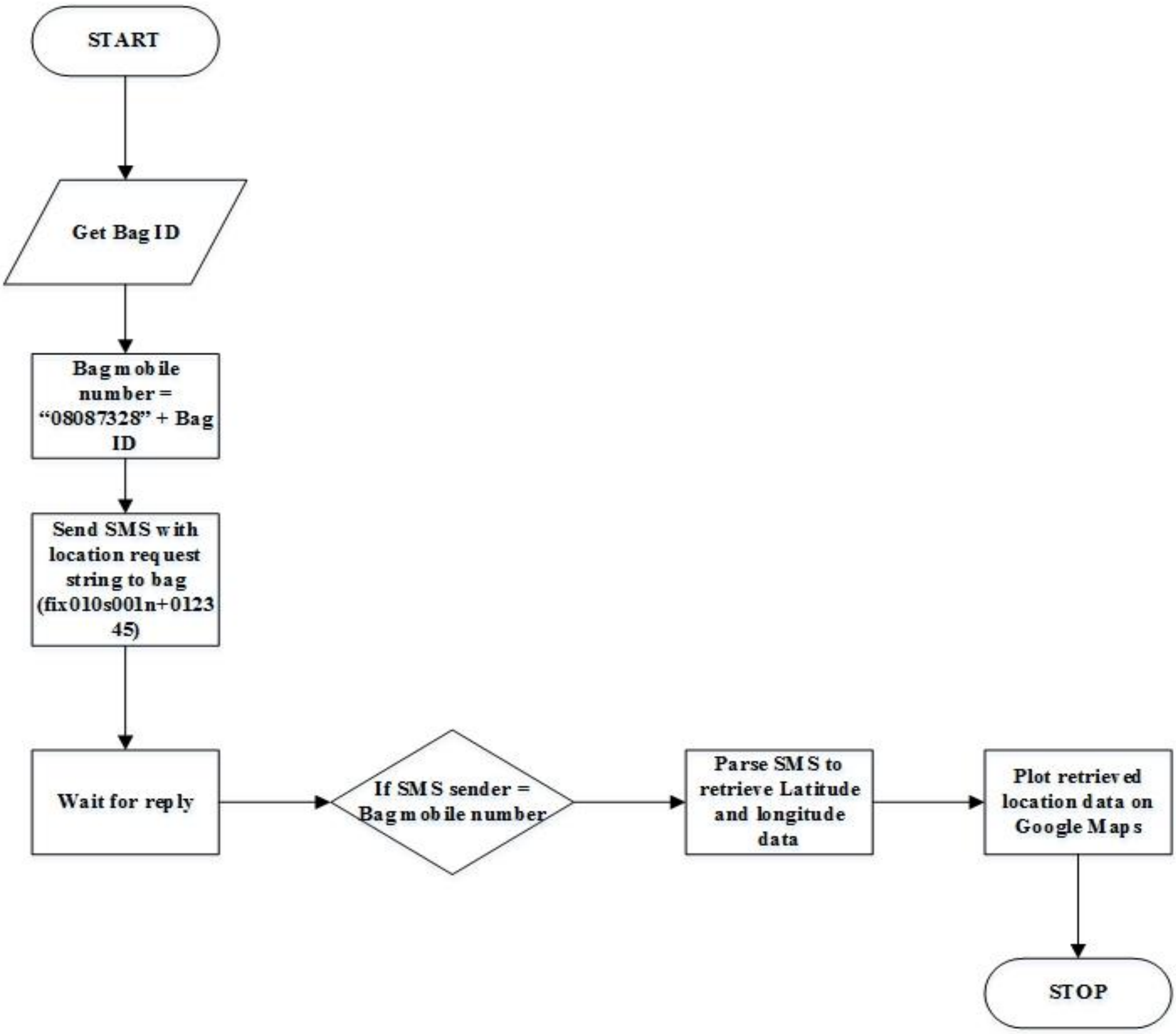

Figure 7: Flowchart for Mobile Application

3.10. System Architecture

The pictorial block diagram in Figure 10 depicts the overall architecture for the smart bag.The system received power through the conversion of solar energy into electrical energy by photovoltaic effect. Extra power was made available for recharging other electronic devices such as mobile phones, tablets, etc. that run on 5V, <1A DC.

The weight of the bag was read each time the bag was lifted. The load sensor experienced a strain that was detected as a variation in resistance. These variations were amplified by the load cell amplifier to a value readable by the microcontroller. The variation was sensed as a change in voltage by the microcontroller. This change in voltage was then mapped to weight.

On request, the location of the bag was gotten by sending the command, 'fix010s001n+12345'. This tells the system to retrieve the location of the bag with a timeout. The geolocation data was always processed with the latitude and longitude extracted. This location data was then forwarded via SMS to the user. An android application installed on a smartphone parsed this SMS and plotted the location on Google maps using the Google maps Application Program Interface (API).

The Raspberry Pi can interface with USB Type-B devices allowing USB flash drives containing video, audio files to be inserted. Videos can then be selected and played using the video player.

Figure 8: Mobile Application Screenshot

IV. IMPLEMENTATION AND TESTING OF THE DESIGNED SYSTEM

From Figure 10, it can be seen that the solar module was placed and neatly sewn into the surface of the bag. The GPS tracker was placed at the top of the bag to allow for minimal signal losses and attenuation. The screen was also placed at the top of the bag for viewing convenience. The weight measurement sub-system was used as the handle of the bag such that whenever the bag was lifted, a downward force resulting from the weight of the bag was registered and displayed on the LCD screen.

4.1. The Power Sub-system

The solar panel was tested to ensure the delivery of adequate power to the entire system.

- The solar panel was placed under direct sunlight and a multi-meter was set to the 20V DC range and open circuit voltage (V_{OC}) was measured. The voltage read under peak sunlight was 6.95V.
- The multi-meter was then set to the 15A range and the short circuit current (I_{SC}) measured was 0.3A.
  Therefore, maximum power can be calculated as:
  $V_{OC} * I_{SC} = 6.95 * 0.3 = 2.085W$

4.2. The GPS Tracking Tests

The Global Positioning System (GPS) module was tested outside. It was tested where it had direct line of sight to the Global Navigation Satellite System (GNSS) satellites with minimal interference. After about 3minutes, a fix was obtained with accuracy to about 20m.

4.3. Weight Measurement Tests

- The weight of the empty bag was taken and recorded. The empty bag weighed 3.92kg
- A mass of 20kg was placed in the bag to get a weight of 23.94kg
- The empty bag was then placed on a standard weighing scale that gave a reading of 3.90kg
- The bag with a mass of 20kg was also placed on a standard weighing scale that gave a reading of 23.9kg.

$$Error\ in\ measurement = \frac{\Delta x}{x} * 100\%$$

$$Error\ in\ measurement = \frac{23.94 - 23.9}{23.9} * 100\% = 0.0017\%$$

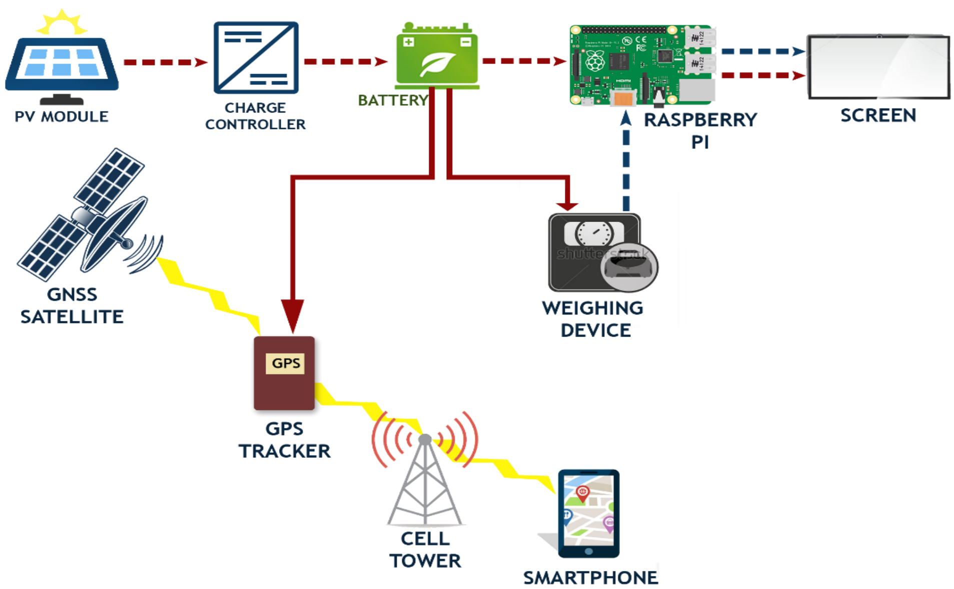

Figure 9: The Smart Bag System's Architecture

Figure 10: Snapshot of the Travelling Companion

V. CONCLUSION

The proposed smart bag has been fully designed, implemented and tested to ascertain its practicability, validity and use to the world. While the prototype features a higher initial manufacturing cost as compared to the conventional travelling bag, it has value added features. Production cost would be significantly lowered should mass production be undertaken.

VI. FUTURE WORK

A rectifier could be incorporated into the system to allow recharging via Alternating Current (AC). This provides the system with an alternative power source and an extended usage time. The GPS tracker patch antenna could be replaced with an SMA antenna or a helical antenna to improve signal reception. The smart bag could also be implemented using a more powerful processor, and a larger Random Access Memory (RAM) to get a better video playback.

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