IOT Based Smart Energy Harvester Linked to Human Body Motions (ISEHLHM).

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Summary
Smart Energy harvesting holds a great promise in near future for generating a feasible amount of electrical power to drive partial circuits in wirelessly communicating electronics devices. This paper presents an overview and progress achieved in RF energy harvesting field. The aim of Energy Harvesting is to harness energy available through environmental resources.. The development of advanced techniques have given impetus to capture, store and manage natural energy by transforming it into electrical energy. Moreover, advancements in microprocessor technology have increased power efficiency, effectively reducing power consumption requirements. From the point of view of wearable electronics devices, the most efficient Energy Harvesting system for energy capturing is that to use devices inserted into the shoes. In this paper, we have presented a novel approach using two different types of Body Strapped Harvesters with the objective to harness energy by capitalizing on energy generated through human body motions to charge a GPS device. Preliminary comparative results of two different scenarios have also been compared on the basis of costs, feasibility and energy harvesting capabilities.

Key words:
Knee Strapper, thermoelectric generator sp-1848, Armed Strapper, heat sink sheets,

1. Introduction

The objective of harvesting is to capitalize on free energy power available by harnessing it from the surrounding such as environment, solar, sea waves, sun lights and human bodies. The technological advancement have increased the productivity of devices in collecting enough amount of energy from the environment such as human bodies and converting them into electrical energy for emergency utilization such as recharge mobile devices. The sufficient advancement in IOT (Internet of Things) tools have amplified the energy productivity, effectively decreasing energy consumption rates. The advancement in IOT have also resulted in change in focus and there is major shift of direction in engineering and research communities to design and develop smart energy tools to utilize energy harvesting for electrical power. The human body is a kind of a repository of stored energy. When human body performs an action such as movement from one place to another place to execute any task then human body actually coverts its chemical potential energy into useful kinetic energy. In fact human body continue to perform many tasks and disseminate various types of energy with different frequencies. Human bodies may also be linked with motor and transform their chemical potential energy into mechanical energy which can be utilized to execute actions. This paper has dilated extensively on the objective of design and development of an innovative smart energy harvester and general purpose device for capturing free energy available from our surrounding. The developed system is cost effective, easy to use, novel and portable through which we can collect the amount of energy and utilize it for chargeable and mobile devices. There are two stages for energy harvesting applications and table 1 shows the various energy levels of human bodies during different activities.1. Capturing human energy and using it to generate electricity for use: using the inherent properties of certain materials that generate an electric current when there is a specific physical change or due to certain physical phenomena.
2. The storage of the captured energy in biochemical, electromagnetic or mechanical forms.

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Table 1. Energy Levels of human body during different activities

Activity	Kcal/hr	Watts
Sleeping	70	80
Lying quietly	80	93
Sitting	100	116
Standing at ease	110	128
Conversation	110	128
Eating Meal	110	128
Strolling	140	163
Driving car	140	163
Playing Violin or piano	140	163
Housekeeping	150	175
Carpentry	230	265
Hiking, 4mph	350	407
Swimming	500	582
Mountain climbing	600	698
Long distance run	900	1,048
Sprinting	1400	1,630

The ubiquitous computing technology help human being to developed efficient smart system to harvesting the energy and utilized it for portable electronics devices and minimize the dependences on power grid stations [1],[2],[3]. The actual electronic energy harvesting take place when the human body linked to smart sensing devices perform an additional task to generate the power energy. These type of devices are call smart active energy harvesters. On the other side, when the user do not perfume an additional task to generate the power, the smart harvester collects the energy power from the routine action of the human body such as normal walking, movement, sleeping and talking and store it for future needs. The literature is replete with references to approaches reported by different researchers on how to harvest the energy power from the routine actions of human being. The common techniques such as electro-static, electro-magnetic, thermo-electro and piezo-electric energy harvesters are being used to collect the energy power from the routine actions of human bodies[4],[5]. These independent harvesters depend on the function of human body to optimize the energy power harvesting sources. The other challenge is to match the specific generator to harvest the energy power in economical manner. The energy sector particularly industrial zones mostly used biomass burners and firewood furnaces to procure the required energy demand. The rest of the paper has been organize in sections providing research background about Smart system. Section III elaborates on essence of the research problem, section four discusses the system's architecture, and section five includes working mechanism as well as flow chart. Section six and seven provides hardware module and software module respectively. Section 8 explains the result analysis while last section present the conclusion.

2. Research Background

The modern era needs to meet unlimited challenges for provisioning a secure, cost effective, clean and sustainable energy supply to reinforce a reasonable standard of living for the common peoples. The unconventional structural and practical resources will regress incrementally in fossil, nuclear, renewable power generation. The smart energy harvesting devices take potential energy from the ambient resources present around us and freely available from the human bodies. The various kinds of ambient resources considered and utilized for potential energy power harvesting are sea waves, winds, solar, vibrations, heel strikers, electromagnetic, temperature, motions and thermo-electric. Till to now, the electrical power produced by smart energy harvesting approaches is small less then watts but the smart energy harvesting techniques get great attention and promotable future in low power smart electronic devices and sensor technologies. The advancement in smart electronic devices and advance technology also a major driven force for smart energy harvesting technology [6], [7] .The fig 1 shows the kinds of energy disseminate by human bodies.

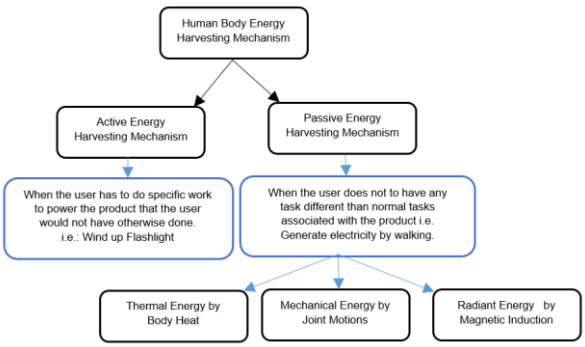

Fig. 1 Human Body Harvesting Mechanism

Some researcher have been start working to address to more efficient power techniques for energy procuring from the environment. The other energy resource such as wind, temperature, solar, sea waves, radio frequency add enough power energy to the power grid station but from the last years, some researcher start to exploit the other resources to generate the power energy such as from the mechanical vibration of electrical, mechanical and electronic machines and human bodies motions.

The least amount of energy power amount from different harvester can be used by different electronic and portable equipment's with low energy requirements such as batteries mobile phones, battery banks, Bluetooth devices, chargeable clocks, LED lights etc. however, support all those devices which has less number of cables as well as small in size. The proposed method is more efficient from

the many aspect such as it is cost effective smart system due to in-complex structure and in-expansive devices which has positive impact on economy and environment. The other aspect is that, the system utilized the sensor technology in contrast of conventional and complicated cabling system [8].Moreover, the smart energy harvesters have capabilities to provide the necessary energy by sensing the critical situations such as telemedicine and biological application which are used to monitor the human body and continuous monitoring the patients' health situation. The smart energy harvester are feasible through miniaturized and wearable harvesters combined with miniaturized sensors integrated in the body without heavy and uncomfortable batteries for the power supply. The developed smart system collects the energy more efficiently as compared to the other proposed system in literature such as piezoelectric, magnetic inductive, electrostatic capacitive, and magnetically levitated.The research contributed to the idea of a Smart Energy Harvester which harvests ambient energy power from human bodies using the combination of sensors and different devices.

3. Literature Review.

Researchers have been actively working on magnetic energy generator for harvesting energy from human bodies. The system in general have moveable magnet that oscillate in a polymeric guide between two magnets at the end of this guide which work as magnetic springs. The harvester has 60mm length and 25mm diameter [9]. The magnetic field is used to produce energy [10]. In Addition the magnetic suspensions provide mechanical stiffness which is determined by the magnetic field associated to the magnets with opposite polarity [11], [12]. The piezo-electric material can be used to produce the electrical energy by compressed and expanding techniques. The piezo-electric material can covert mechanical energy into electrical energy [13]. These material are crystal based in which electricity is generated by the pressure (direct effect).literature reported that, some researcher used the piezo-electric transducer and mechanical vibration spectrum to harvesting the energy power from the human bodies. Moreover, the piezoelectric transducer is based on the principle of piezo-electric effect. The piezen means to squeeze or press [14],[15]. When mechanical stress or forced is applied on quartz crystal it produce electrical energy on the surface of quartz crystal. The piezo-electric effect is discovered by different materials such as during the micro phonic conversation the produced sound pressure has been converted into electric signals and these signals again amplified to produce louder sound [16,17]. Another experiment conducted by researchers to covert the mechanical energy from constant cyclist pedaling has resulted in producing a sufficient amount from 100w to 200w through the use of mechanical power has been disseminated[18],[19], [20], [21].The Dr. Larry, invented kinetic energy from the human walking. The researcher convert the kinetic energy to electrical energy via using an electromechanical mechanism [22], [23],[24],[25], [26]. The literature reported many other state of art research where different researcher convert the breath energy into electric energy to recharge the small electronic devices [27], [28], [30],[31].

4. Issues & limitations in the existing systems

Most of the existing systems are proprietary based and do not have the provision for commercial usage. Moreover, the systems are exorbitant in terms of hardware, and have complex interfaces. The design of the proposed prototype system is cost effective and architecturally feasible compared to other existing systems due to low cost and user friendly interface

During the course of our research, we have found systems which have been used to control home appliances by using wired and wireless technologies. However, the wireless technologies provide limited coverage such as Bluetooth has 20 meters, Wi-Fi has 100 meters, and ZigBee has 1000 meters in range. To avoid the coverage limitations, we have proposed a smart system to monitor and control the energy losses remotely. The ISEHLHM system has been developed with GSM technology along with android based application and ardunio microcontroller. The smart system has successfully demonstrated its ability to monitor and control the domestic wastage of energy at homes and also provided an easy interface to control the home appliances remotely.

5. Architecture of Prototype System

The architecture of prototype system categorized into two-prototype system, the first one is Prototype module of Arm Strapped harvester and second one is the Prototype module of knee Strapped harvester.

5.1 Prototype module of Smart Arm Strapper

Our first prototype is made from 15 series thermos electric generator (TEG-SP1848) in the shape of belt wrapped around arm to convert body heat into electricity, this prototype can be worn over arm, thigh, neck etc. over thermoelectric generator we use different type of hear sink that cools upper side of TEG. Our output is depending on atmosphere temperature, speed condition of body because we have to build more and more temperature difference

between atmosphere and body whenever we walk our body temperature is increased and atmosphere temperature decreases due to airflow at the upper side of heat sink as a result our output increased. Fig 2 depicts the model of smart arm Strapper.

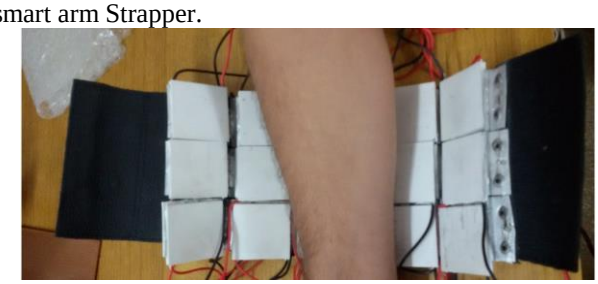

Fig. 2 Protoype Model of Smart Arm Strapper

5.2 Prototype module of Smart knee Strapper

Our second prototype is smart knee Strapper at which we convert knee motion into electricity through DC motors used as generator. We have made use of an Elastic belt, which is wearable over the Knee, and this 3-volt harvester is fix over the side of the belt that can be move through 0 to 180 degree, as human leg can move easily. Whenever human started walking, generator will generate electric output that will go to circuit, which can be stabilize and boosted according to application. The fig 3 shows the prototype model of smart knee stepper.

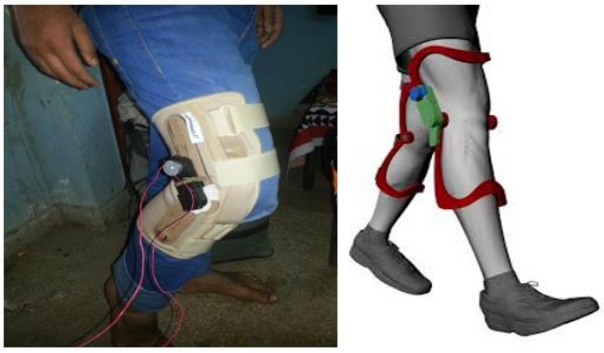

Fig. 3 Prototype Model of Smart Knee based smart Strapper

6. Operational Mechanism and Tools

Various tools used during the course of designing proposed model, includes screw drivers, plastic sheets, gearbox, motors, heat sink sheets, thermoelectric generator sp-1848, knee frames, belts, different type of buck and boost convertors, wire cutter, wire stripper, different types of wires, soldering iron, Ardunio Uno, LCD display, Voltage and current sensors and others. The fig 4 depicts required hardware of the prototype model.

Fig. 4 Operational Mechanism and Tools

7. System Testing and Results Analysis

Various tests has been perform with different methods, under varying environmental conditions and discrete results got from each tried method. Factors like different walking speed, models, different conditions of Body, different times of a day and different Fields were consider.

7.1 Testing results of Arm Strapper in volts

The fig 5 demonstrates active energy power load produced by smart arm Strapper. The design prototype arm Strapper has been install on wrist of human body, which collect the movement energy from the wrist.

Fig. 5 Wrist based Smart Harvester

7.2 Energy Potential of Arm Strapper at different conditions of Human Body

The Table 3 and 4 shows the results of at different conditions of different bodies, in which different average results were collect.

Table 3. Represent the various parts of human body with respective of their active energy power load collected by the arm Strapper.

S.no	Activity	ATM Temperature	Body Temperature	O/P(volts)
01	Running	26	41	1.5 v
02	Walking	26	38	1.0 v
03	Siting	26	37	0.9 v
04	Sleeping	20	37.77	1.4 v
05	Standing	26	37	1.0 v
06	Gyming	26	40	1.5 v

Table 4. Active Energy Power Load of Various Human Body Parts

Human Body Heat Parts	Temperature (C)	PLED (mW)
Leg	35.5	9.8
Top Wrist	36	22.7
Wrist	37	23.6
Palm	38	24.6

7.3 Testing Results of Knee Strapper in volts

The fig 6 elaborates the active power load in human bodies, which can be utilize for different purposes. The smart knee Strapper harvesting the amount of energy from the knee movement of human body.

Fig. 6 Depicts the active power load management on android application

The Table 5 shows the various walking speeds of human body and the knee Strapper harvesting the different amount of energy from gait approaches.

Table 5. Active Power Load of various Human Gaits

S.No	Walking Speeds	(m/s)	Output (volts)
01	Slow walking	0.5	0-2.47
02	Normal Walking	1	3-5
03	Jogging	2	5-6
04	Slow Running	3.5	7-10
05	Fast Running	6	10-20

8. Graphical representation of Obtain Results

The following figures shows the graphical representation of various prototype model results. The fig 7 shows the graphical representation of Active Power Load on Human Body Wrist and fig 8 depicts the Active Power Load of Human Gait.

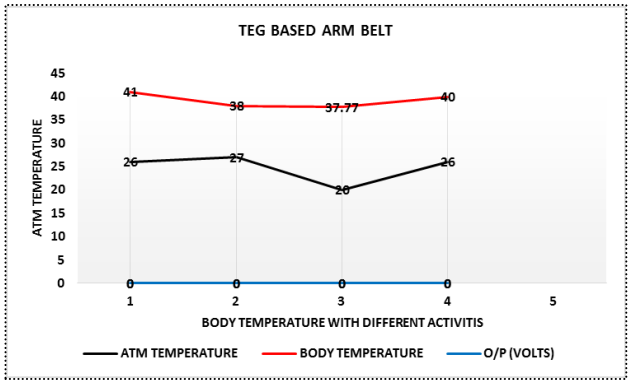

Fig. 7 Graphical Representation of Active Power Load of Human Body Wrist

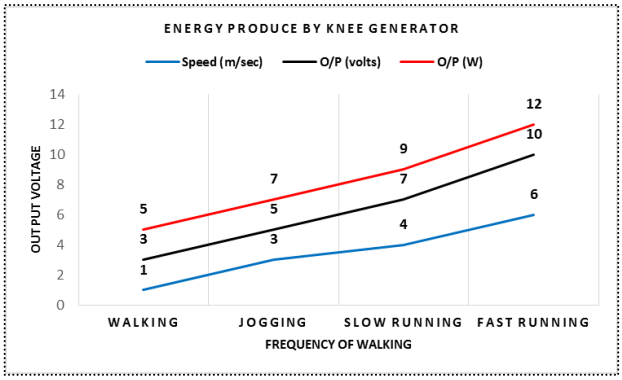

Fig. 8 Graphical Representation of Active Power Load of Human Gait

9. Conclusion

The main theme behind this study was to develop a suitable Thermal and Mechanical energy scavenger for

human motion and heat which could supply power to body worn sensors or electronic devices. We have also introduced the structure of a thermoelectric generator, electromagnetic generator that could be beneficial over the cantilever structure form different body energies. The prototype generators produced 3.7–15.0 volts when placed at the knee over a belt or frame. Which worn during walking and slow running. These results indicate that a useful amount of voltage and power could be generate from the human knee motion. This Knee generator prototype can be utilize at the time of Jogging, running and for military usage at remote areas. Moreover, other prototype model of Body Heat Harvesting system using Thermoelectric Generators, this prototype is a kind of a belt that can be wear over Leg, Wrist, Forearm, Neck, and Arm. The series of 15 TEG modules that can be able to generate efficient energy to charge the portable devices and small body area sensors. In other words we can make up for the Power demands of portable devices like body area sensors and Nano-sensors due to our efforts of using different TEG modules and different Motors using as a generators.

10. Future Work

As amply established, it is possible to capture energy from various actions of the human body such as walking, cycling, arm movements etc. Finger pressure, respiration and blood pressure. One of the challenging future applications could be the development of a storage to store the harnessed energy in feasible amount and viable form for future usage.

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