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VIRTUAL REALITY-BASED HUMAN ENERGY HARVESTING

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ABSTRACT

Many schools in rural India hardly have power line installed, hence demand for electricity in those schools can be partly fulfilled by human energy harvesting. Children are abundant sources of energy and part of energy they spend on gaming can be used to generate electricity. This paper describes building of an interactive gaming system with racing video game where player's virtual character in the game will accelerate, decelerate and turn depending on the physical pedaling and handle movements respectively. In doing so, this electromechanical system will not only provide electricity but also an entertainment with added health benefits and causing no harm to environment. A Virtual Reality (VR) kit is also installed which adds to the thrill among children and enhances the energy generation. The paper discusses the basic theory behind the method. Results of experiments on the laboratory prototype are presented to illustrate the practical effectiveness and importance of this proposed approach.

KEYWORDS: Bicycle, pedal power, racing game, gamepad, Virtual Reality, human energy.

INTRODUCTION

Energy is one of the most fundamental parts of our universe. Generation and consumption of energy are very important for socio- economic development. From recent survey, it has been found that scarcity of energy has become a burning question in developing nations due to various factors, some of them are:

- Depletion of non- renewable resources,
- Rising price of oil and petroleum,
- Increasing population and hence resource scarcity,
- Global warming.

About two billion people in the developing nation don't have the access to electricity. India is one of those nations where 600 million people don't have the access to electricity. This statistics may rise enormously in the upcoming future. The various concerns coupled with increase in oil and petrol prices led to the advent of renewable energy sources like sun, rain, wind. It has been observed that there is also an increasing government support towards this sector. Though solar and wind energy are the two major sources of electricity, yet there is a falling usage of these sources due to cost, availability issues, and maintenance. These technologies are still far too expensive for developing nations, where about half the population has income of less than two dollars a day. [1]

Use of human energy to generate electricity is not a new technology. In recent years, some interesting developments in the field of human power conversion has been witnessed. In the present paper, a method of harvesting significant amount of energy from children's playful activities is proposed. In the proposed method, human energy is harnessed by bicycle pedaling which is an exhaustive work in a boring environment. So, to make it interesting, conventional pedal system is interfaced with PC games using sensors, controllers and VR hardware. Therefore, the person pedaling can be simultaneously engaged in video gaming using the same physical pedal system, where the virtual character in the game responds to peddler's movement and is used to power both dc- operated appliances and to ac- operated appliances using inverters and control circuitry. This pedal system will not only generate electrical energy but also provide health benefits to children. The gaming environment is enhanced by Virtual reality hardware where the user experiences his presence in an environment where they are not actually present.

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History of pedal powered machines

Ever since the arrival of fossil fuels and electricity, human powered tools and machines have been viewed as an obsolete technology. This makes it easy to forget that there has been a great deal of progress in their design, largely improving their productivity. In the late 19th century, pedaling appeared to be the most efficient mechanism to harvest human energy. But as electricity became cheaper, people seemed to have lost interest which stopped further development. Pedal power appeared in 1870's, is considered as the cleverest innovation in applying human power to rotary motion. Some of us still use it as a means of transportation, but it is rarely applied to stationary machines anymore that is, pedal power. Later, this basic direct power transmission mechanism was replaced by chain drive and sprockets. Pedal power is a product of the industrial revolution. Many organizations worked on the applications of pedal powered systems. Although their efforts did not result in commercially available machines, a great deal of progress was made. Research in pedal powered systems halted for nearly two decades after oil crisis began halfway during the 1990's due to global warming. But, the advent of green technology gave a resurgence to pedal powered systems and is mainly aimed at generating electricity. [6]

BLOCK DIAGRAM

The proposed system consists of two major parts: power generation and entertainment. Power is generated by conventional method of pedaling. Generating power by pedaling is an exhaustive task. To make this task interesting, gaming is introduced along with power generating machine. The gaming experience is introduced by interfacing sensors with controller IC. To have immersed gaming experience, Virtual reality (VR) kit is also added which is a head-mounted display. This VR device is supported by Android app which acts as a client between PC and the device. A schematic of the proposed human energy harvesting system that combines VR-gaming with bicycle pedaling is shown in Figure 1.

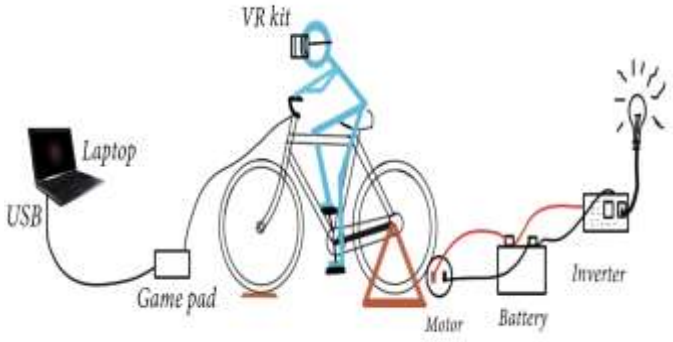

Fig.1 Schematic diagram of the proposed system

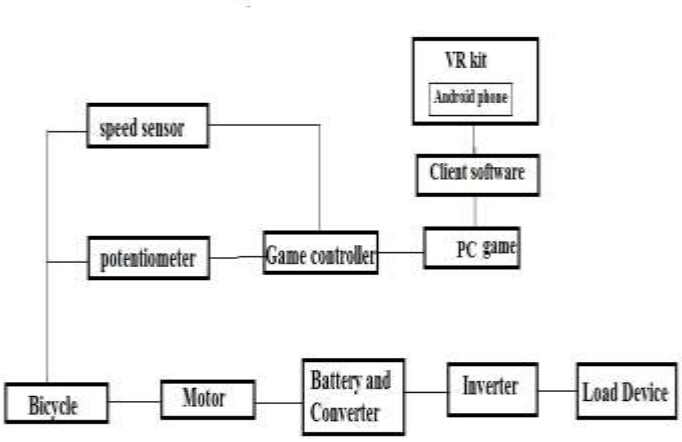

Fig.2 Block diagram

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Hardware setup

- An existing bicycle is modified with a wooden stand attached with the axle of the rear wheel.
- Motor MY1016 is a 24 volt, 2650rpm, 13.7A, 300 watt high power DC motor used in scooters.
- A potentiometer is used here to sense the direction of the handle.
- Gamepad controller acts as an interface between bicycle and the computer game. It is hacked in such a way that changes in value of potentiometer mounted on bicycle handlebar will result in change in direction and pedaling bicycle will act as button 6 being pressed on a gamepad.
- There are various sensors that can be used to measure the speed of the motor like IR sensor, Hall Effect sensor, relays, and feedback mechanism. The paper implements two ways to measure the speed. One of them is using IR sensor, it comprises of a pair of IR emitter and IR receptor. Here, it is used to detect acceleration as well as deceleration of pedaling. The other method is using a feedback mechanism. This feedback signal is given to the data pin of gamepad IC.

Detailed description and working of hardware setup

First and foremost work that is done is modification of bicycle so that it can be used for pedal power generation. Rear wheel of bicycle is supported using wooden stand. Generator is also mounted on the wooden stand and is meshed with the rear wheel in friction drive mechanism. Generated power is stored in a 12V 1.3Ahr battery. An USB gamepad is hacked in such a way that potentiometer that is used to sense handle movement. Button 6 on gamepad receives signal from speed sensor module which is mounted near generator. USB gamepad is connected to a computer device which automatically takes care of device drivers enabling user to play any racing game that supports gamepad. This arrangement also provides an approximate gearing up ratio of 1: n.

Fig. 3 Pedal power transmission mechanism

OUTPUT POWER CALCULATIONS

On an average daily human calorific consumption is about 2500 kcal that is equivalent to 3 kilowatt-hours. [1]

TABLE I
ENERGY CONSUMPTION FOR DAILY LIFE ACTIVITIES

Activities	*Consumption*
Walking	400watt
Sleeping	80 watt
Swimming	600watt

It can be said that day-to -day human activities consume large amount of energy, as shown in Table I. Therefore the net energy available for conversion is quite limited. Table II lists some important power requirement of common household appliances. [1]

TABLE II
POWER REQUIREMENTS FOR REGULAR HOUSEHOLD APPLIANCES

Appliances	*Energy requirement*
Fluorescent light	10-40 watt
Shaver	15 watt
Desk mini fan	25-40 watt
TV(24 in)	80 watt
Mobile charger	5 watt
Laptop charger	15-20 watt

In the present work, harnessing the human muscle power of children playing in public spaces such as schools, gaming hubs, hubs and so on is proposed. Such an energy conversion is playful and hence does not require deliberate effort. For human power conversion systems to be useful several constraints need to be considered: low-cost, limited-skills requirements, safety and comfort to humans, and environment-friendliness.

Motor speed calculations

Cycle wheel diameter (D1) = 68cm
Motor wheel diameter (D2) = 9cm
We know, $\frac{D1}{D2} = \frac{w1}{w2} = \frac{\tau 2}{\tau 1}$
D is diameter, w is angular speed, and τ is torque
Therefore, D1=8*D2and w1=8*w2
Speed characteristics of motor are measured with the help of voltmeter, tachometer, and reflector.

TABLE III SPEED CHARACTERISTICS OF MOTOR (MY1016)

Output voltage in volts	Speed of bicycle in rpm	Motor speed in rpm
3	43	117
3.8	70	280
5	90	500
6	103	1000
8	150	1800
12	230	2200
14	265	2400
16	280	2515
18	311.6	2670

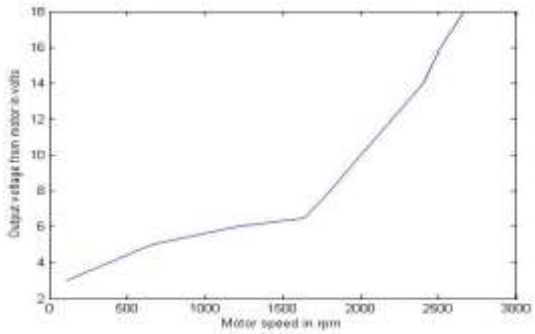

Fig.4 Graph of speed characteristics

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Output power calculation

Average output voltage from motor on pedaling is 14V
Current is limited to 2.5 A.
Choice of load: Thin metal sheet of low resistivity.
Average power generated= 40- 50 watt.

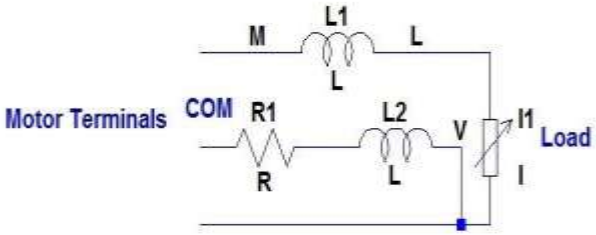

Fig.5 Power measurement circuit

TABLE IV POWER CHARACTERISTCS OF MOTOR MY1016

Output voltage in volts	Power in watts
6	11
9	18
11	20
14	32
16	50

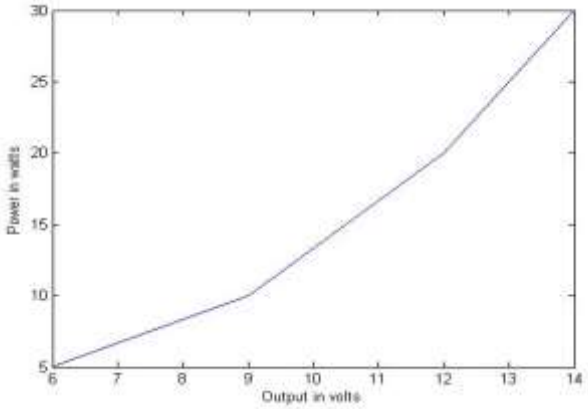

Fig.6. Graph of power characteristics

The average energy generated on pedal power by scooter motor is 50 joules/sec.

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Fig.7 Lighting 45 watt DC bulb with pedal power

ELECTRONIC SYSTEM DESIGN

Potentiometer set-up

A schematic diagram of the potentiometer mounted on the handlebar is shown below,

Fig.8 Schematic diagram of potentiometer set-up using CAD modeling

Fig. 9Laboratory set-up of potentiometer

Speed sensor set-up

There are various sensors used to measure speed and direction of rotation of motor which is necessary to accelerate or decelerate or to cause some change in the video game based on how it is configured. For example, in educational games pedaling speed can be used for toggling of upward and downward radio buttons. In this paper, the pedal cum gaming set-up is tested using NFS carbon car racing game. There are other sensors like IR sensor, Hall Effect sensor

and motor encoders to measure the speed. Initial test was done using IR sensor. A black mark is made on the motor cog (wheel in this case) and the IR sensor tracks the mark and gives high pulses to the controller and the acceleration and deceleration is achieved. A major disadvantage in this test is that IR sensor working at 35kHz, hardly catches the speed of the motor at very high rpm; hence the acceleration is measured up to some low rpm using IR sensor.

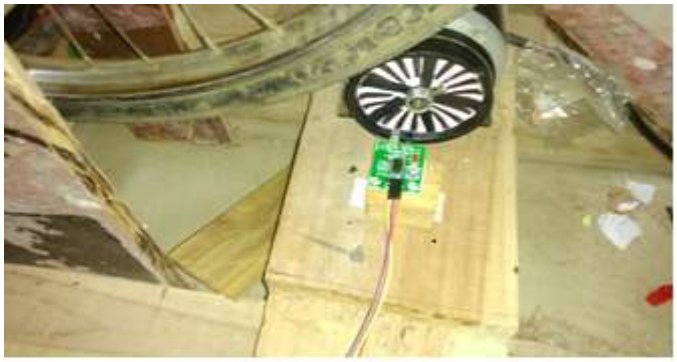

Fig. 10 IR sensor measuring acceleration and deceleration

Finally test was done using feedback mechanism. Motor's output is connected to various load devices; a part of the output is taken feedback and is used to accelerate and decelerate the character in the game. IC used here is 7805 regulator IC. The input to the IC is pedal power generated voltage and output is constant 5 V. This 5 V is given to the data pin of game pad IC and acceleration and deceleration in the game is controlled. Since gamepads are low power consuming devices, therefore power used in this mechanism is very minimal compared to the power that is generated by pedaling.

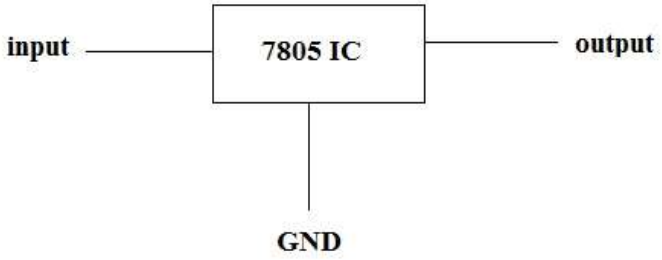

Fig.11 Block diagram of regulator

C. Hacked Gamepad

The gamepad IC used here is JW24A10L-P. It is a low cost 24 pin DIL A to D converter IC. It has 3-analog axes, each of 10 bit resolution. In this work, handle movement and acceleration are sensed and the analog data is given to the ADC which converts to digital data and passes to the computer over USB.

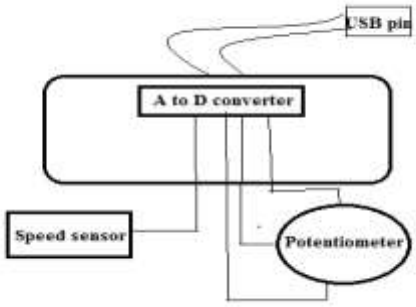

Fig. 12 Schematic diagram of the gamepad hardware

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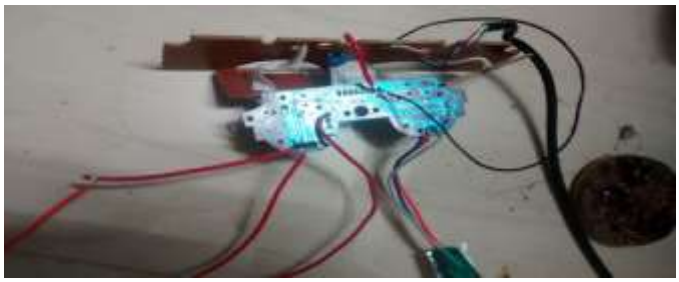

Fig.13 Hacked gamepad

D. Virtual Reality

Virtual reality, also known as computer-simulated reality, is an immersive technology that replicates an environment, real or imagined, and simulates a user's physical presence that environment in a way that allows the user to interact with it. Virtual realities artificially create sensory experience, which can include sight, touch, hearing, and smell. There are various advantages of virtual reality. Virtual reality in defense sector helps the armed forces to train themselves in a virtual environment to enhance their skills. Virtual reality plays a major importance in urban design, architectural design, fine arts, and gaming. The advent of Oculus Rift gave a new shape to virtual reality. Oculus Rift is a head mounted display fixed with lenses to witness virtual environment. The device is powered by NVDIA Graphics, Intel i5 processor, HDMI video output. This system enhances the gaming environment. A low- cost VR kit is implemented in this system, where a rider observes his or her presence in a virtual environment (game in this test). This head mounted VR kit is supported by Android phone and is interfaced with the laptop using client software 'Trinus VR'.

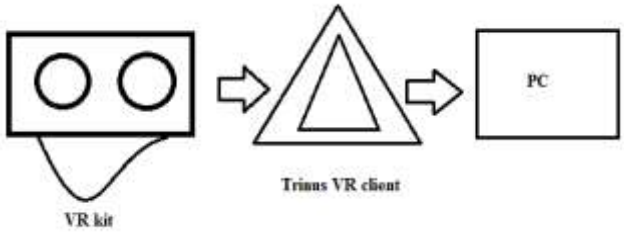

Fig. 14 Interfacing diagram of VR kit with PC

Fig. 15 User wearing VR kit

RESULTS AND DISCUSSION

The implemented system is used to generate power by riding bicycle where stationary rider charges mobile phone in about one and half hour. Same system is used to light up DC bulb of 45watt.

Final system set up

Fig.16 Final system set-up

Fig. 17 Mobile charging

In addition to being used as backup power mechanism it can also create energy and environmental awareness especially among school going kids. This method is one of the means to harness human power at public places like school playgrounds, railway platform, waiting rooms and so on. Such an energy conversion is not only playful but also provides health benefit, too.

B. Bill of Material (BoM)

TABLE V BILL OF MATERIAL

Parts/Components	Price in INR
Bicycle	1500
Scooter motor(imported)	2500
Game controller	500
Potentiometer	10
IR sensor or 7805 or Hall sensor	50
	300
VR kit	200
Wires and frugal items	
Total	5100 /-

For this system to be implemented in developing countries several parameters needs to be addressed like low cost, low resources limited skills requirement, low safety and green. From Table V, we can observe that an affordable system can be designed without seriously affecting the efficiency as more the number of children involved in play, more is the generated power.

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C. Discussion

The system can be improved by generating more power using gear mechanism which will increase the turn ratio. Entertainment value of system can be further enhanced by including other features that game has to offer such as 'nitrous boost' using push button or sensor. Further, we can make hub of this system where multiple users will be engaged in same racing game, competing with each other controlling their virtual character similar to LAN gaming. This will not only generate more amount of electricity but also gaming experience will be more immersed. There are many ways to make this system more exciting as this system supports any game as long as it is compatible with hacked gamepad. So, it is possible to have many children playing football game where bicycle pedaling corresponds to running of virtual character.

Interactive gaming adds fun element in this system, but it is also possible to inculcate educational games like puzzles, quizzes etc. in this system so as to sharpen children minds. Childhood obesity which is a major challenge these days can be tackled to some extent by this methodology [10]

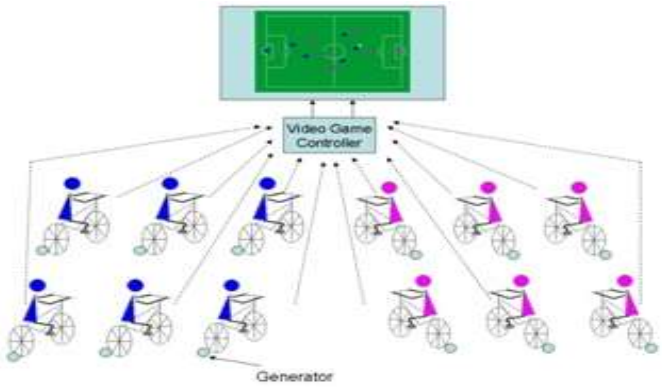

Fig. 18 Multiple user gaming experience

Many people who regularly go to gym feel bored during some of the gym routines such as pedaling or walking. They do these routines just for the sake of getting them done. A system like this can be used to add fun element to their gym routine and simultaneously generate electricity, too. Interactive gaming cycle is one of many projects in the field of renewable energy that is trying to tap power of human body. Experiments show that electricity generated by vibrations of dancer on dance floor is sufficient to charge cell phone. [7]

CONCLUSION

A method for human power conversion based on riders's pedaling is successfully prototyped.Power generated is used to light up DC bulbs,charge laptops and cellphones,fan etc. Also this system can be used to prevent childhood obesity. Resultsobtained are encouraging for the system to be realizedat public places with additon of some ergonomic aspect.

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