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Selfsustained Treadmill

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Abstract: This paper discussed the concept of self-sustained treadmill using physical activity of humans. During the step-by-step walking on treadmill calories burned and using this concept can power up the treadmill. It also incorporated the power optimization using installation of PZT tiles on treadmill and prototype model also incorporated in the study. The deployment of PZT-based tiles is crucial, coupled with the use of available renewable energy sources. According to this viewpoint, the purpose of this study is to determine the power optimization (PO) using tile deployment in treadmills. This power can be utilized to power up the treadmill and other equipment of the gym. In accordance with the frequency of movement among the various places of gym and equipment more energy can be generated to power up the gym equipment. In the study Linear regression (LR) machine learning techniques employed for power optimization of treadmill. These techniques are used to optimize tile power in relation to sensor quantity and subject weight. The data was acquired using the gym. Two alternative statistical criteria (MSE and accuracy) are discussed in the paper to assess the efficacy of these algorithms. Model accuracy was expected to range from 0.93 to 0.9946 by the MSE of models. In conclusion, the present paper is reporting that the LR algorithm can be used for the tile deployment on a suitable place of gym. The tile deployment was also anticipated by the LR algorithm, and as a result, the tile could be placed on the treadmill because the frequency of movement is more as compared to other places.

Keywords: power Treadmill, subject, weight, optimization, Security, linear regression, SVR and RF

1. Introduction

In the current scenario of extremely occupied lifestyles, “metabolic syndromes” have become very common. Research shows that this condition can only be reversed through lifestyle management if medication is not preferred. Disturbed or faulty lifestyle significantly affects physical and mental health as well. Consequently, a lot of psychological difficulties are triggered along with the comorbidities. These may be mood dysregulation, sleep related difficulties, diabetes, cardiovascular diseases etc[1]. Physical activity such as aerobics, jogging, swimming, cycling, walking, gardening, and dancing etc. may work as a pivot in the management of such problems [2]. Physical activity and exercises have proved to energize and improve mental health [3]. A recent study conducted on a sample of healthy elderly people has also endorsed these findings [4]. by endorsing the role of moderate exercise in improving cognitive functions of the said sample. Similar findings were achieved by Alghamdi [5] who had studied the effects of moderate aerobic exercise on cognitive abilities and redox state biomarkers in older adults. Hence, in the presence of all this evidence-based literature [6]-[7], it will not be an exaggeration, if physical exercise is designated as an “energy boon” for the present era.

Due to the epidemic, everyone is concerned about their health, and leading a healthy lifestyle is essential to living a long life. That is why there was a rapid rise in energy usage. Due to contamination, most individuals arrange their home gyms. The self-sustaining train mill power optimization is the focus of this paper. Figure 1 illustrates the researcher's report of numerous self-sustaining energy generation sources. Using wearable sensors as described in [8] through [14], it may produce energy from any type of physical movement. One approach to maintaining fitness for everyone is through physical activity. According to the survey, 80% of respondents are aware of it and incorporate it into their daily routine for a healthy existence. Due to unhealthy lifestyle and sedentary work life early, cardiovascular disease reported in adolescents and elders. As per the WHO database most of the deaths were due to silent attack. These self-sustain treadmills help to maintain a healthy lifestyle.

In the last decade due to lack of natural energy resources many renewable energy sources have been generated like solar and wind [16]. These sources are successfully installed and fulfill the energy requirement. But these resources are not cost effective. Hence other alternative techniques are also desirable like PZT, Electro dynamometer. These techniques are cost effective but only give better results for specific conditions like dance floor, stairs, Toll Plaza, and speed breaker [17]. Further advancements work on PZT based techniques for enhancing the power like changing the quantity of sensor, alignment of sensor, dimension of tile etc. [18]. Furthermore, the few suitable deployment of tile for power optimization [24]-[29] Several machines learning algorithms have gained understanding for the same in recent years. These algorithms support the development of intelligent machine models that can accurately and efficiently deliver the necessary power, hence minimizing the need for further human design work on diverse prototype models. This paper presented the placement of designed prototype model on right place of machine (Treadmill) to maximize the power generation. Figure 3 depicts the installation of the model on the appropriate machine (Treadmill) for maximum power generation. As a result, the tested model has been placed on the treadmill base because this is the most sensitive area for power generation. This study is appropriate for a variety of settings, including a dance floor, a train station, and a stairway. Because of sensor malfunction after a specific limit, this model is only suited for human movement. Many theoretical review of a PZT tile that has not yet been commercialized, cost effective and optimized [29].

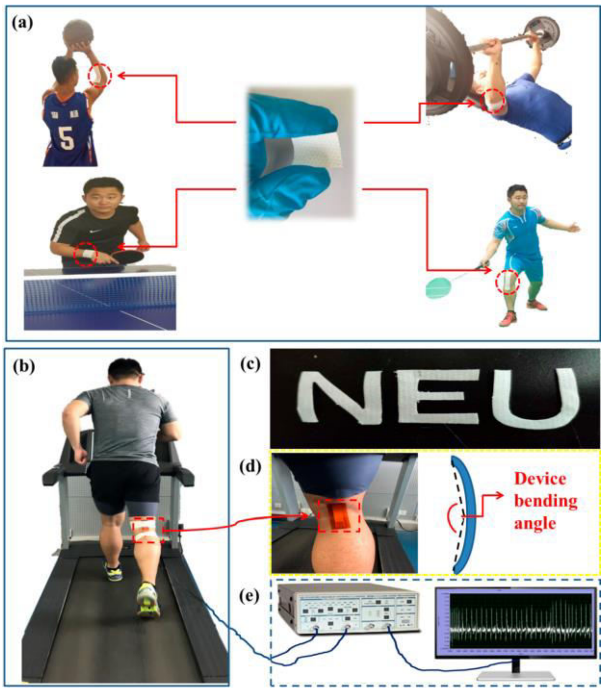

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Figure 1. PZT sensor used for generating the energy via various movement of body parts(a)-(e)[8]

2. Materials and Methods

2.1 Treadmill Description:

The treadmill, a piece of exercise equipment, has been chosen for the PZT tile deployment for energy collecting. The treadmill is a piece of fitness equipment that allows users to exercise at home or at a gym. There are numerous people in the gym, including trainers and trainees. There are several places in the gym where the tile for power generating can be installed. These are the places with the highest volume of daily traffic. Since treadmills are where continuous running and walking is typically done, the tile may usually be placed there for greater output generation. Consider the common treadmill as illustrated in figure 2[2] to calculate the cost estimate and tile deployment. The dimension of this in LxWxH is 81x34x55 (206x86x140 cm) in inches. The tile dimension is 30x30 cm using 36 sensorstested. Using prototype model as shown in figure 3. As per the dimension of treadmill the 12-tiles module should be placed on the base of tread mill for the power generation. The power analysis of treadmill for one footstep calculated i.e., is 89 μW. The cost estimation of tile deployment is 10560 Rs. The power analysed treadmill done for three paces walking slowly, walking fast and jogging. In this the pace of human would be 2, 3,5 mph. Hence as per the observation while increasing the pace more power generation. The calculated power at walking pace 2mah for 2000 footstep is 178 mW. and power at walking pace 3mah for 3000 footstep is 268mW. Further on the jogging pace 5mah for 5000 footstep is 445 mW.

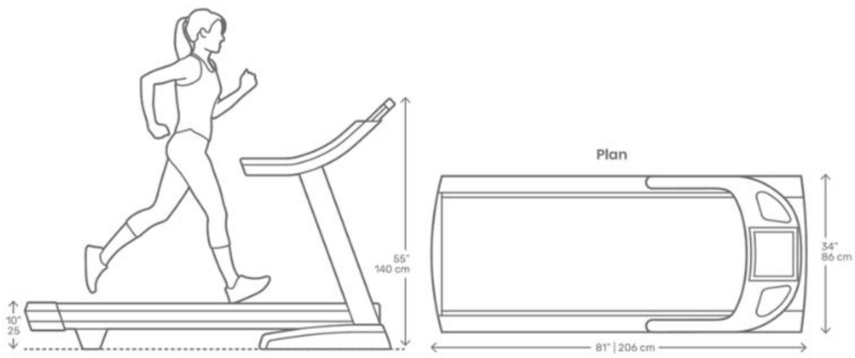


Figure 2: Treadmill dimension [15]

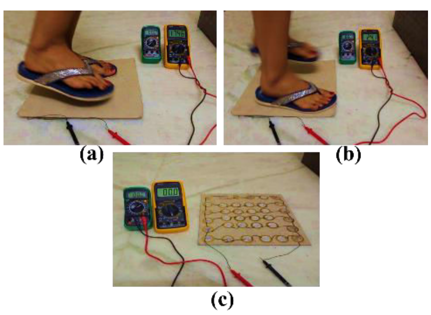


Figure 3: Protype testing of design tile.

2.2 Power analysis:

No. of Tile Module:Plate Area ÷ sensor Area

$:\frac{(L\times W)}{\pi r^2}$

$: (300 \times 300) \div (3.14 \times 24 \times 24)$

:50

2.3 Power estimation of tile:

The power optimization technique for PZT tile is RSM [24]. This method finds the correlation between input and output parameters. The other power optimization technique is the Taguchi method [27]-[28]. This method is used to select the best tile designing parameters. As per the analysis of obtained result the values of the different processing factors, such as weight (62.2 kg), frequency (2.9 Hz), and rigidity (1046.35), that must be employed to achieve the greatest output are derived from the trial results. The third and fourth optimization method create and verify ML model upon the most pertinent parameters in estimating the strength of PZT tiles and the ideal location for their installation on a college campus.

Average force(F):

$$F = 75 \times 9.8$$

Average foot length and width: 250 mm and 95 mm

PZT dimensions: 19mm and 15.8 mm

PZT diameter: 40 mm

$$stress(\sigma) = \frac{F}{\pi n r^2}$$

$$= 75kg \ \times 9.8\, m/s^2) \div (\pi \times 36 * (9.5^2 - 7.9^2) \times 10^{-6})$$

Open Circuit Voltage(V):

$V = g33 \times t \times \ \sigma$

$= 26 \times 5.6 \times 10\text{^} - 6 \times 233555.76$

$= 34V$

Charge(q)=

$q = d33 \times \ \sigma \times \pi \times r^2$

$q = 290 \times 233555.76 \times 3.14 \times (9.5 \times 9.5 - 7.9 \times 7.9)$

$= 5.9 \times 10^{-9A}$

Power of one Sensor(P) = V × I

$$= 20.6 \times \ 10^{-8}\text{W}$$

Power of tile(P) $= 36 \times 20.6 \times 10^{-8}$ W

$= 7.42\mu W$

Power of the tread mill tile for one footstep(P):

$= 12 \times 7.4\mu W$

$= 89\ \mu W$

Walking on treadmill at moderate pace(2mph)

Power generation at moderate pace:$= 2000 \times 89$

$=17800\ \mu W$

Walking on tread mill at moderate pace(3mph)

footstep is 3000.

Power generation at moderate pace$= 3000 \times 89$

$=268000\ \mu W$

Walking on tread mill at moderate pace(5mph)

footstep is 5000.

Power generation at moderate pace: $= 5000 \times 89$

$= 445000\mu W$

2.2Tile Deployment strategy:

The analysis of tile deployment was done on the middle point of the treadmill stated above where people move around a loT. The movement of people on the treadmill usually on the middle of treadmill. It usually skips the last and starting and side place of the treadmills. Where human foot movement during running.

Therefore, to calculate the number of tiles required for the treadmill find the dimension where the movement of human is more. The counting the amount of footstep per hour and minutes is also calculated using the formula. As per the routine usually gym timing 8AM to 10 AM and at night 6PM to 10 PM.

Number of people counted per day and month as shown in figure 3 is usually on treadmill due to cardiovascular health and lose more calories. After the observation the movement of person usually encounter during the 8AM to 10 AM and in night 6PM to 10 PM. Hence the deployment of tile on this place can generate more power. The power analysed treadmill done for three paces walking slowly, walking fast and jogging. In this the pace of human would be 2, 3,5 mph. Hence as per the observation while increasing the pace more power generation.

The frequency of movement during pick hour determines the tile deployment. As a result, according to the examination of data on the tread mill at different interval. the middle place of treadmills that are best suited for the deployment of tiles. The number of tiles deployed is determined by the tile's area and path length. Equation (1) will be used to calculate the number of tiles needed to complete the suggested path [1]. As per the tile effective area of tread mill i.e.180 cm and 60 cm hence the quantity of tile module calculated i.e. 12.

$$n = \frac{Li}{Lt} \qquad (1)$$

Where n is the number of tiles

L_i: Length of pathway

L_t: Length of tile

Quantity of tile calculation for the entrance gate:

Path length of Treadmill: 206 cm

Path width of Treadmill: 86 cm

Tile length: 30 cm

Unused space length: 206-26=180 cm

Unused space width 86-26=60 cm

n=180/30: = 6 tiles

n=60/30=2

total tile on treadmill: 6*2=12

similarly, the quantity of tiles can be calculated for other equipment also.

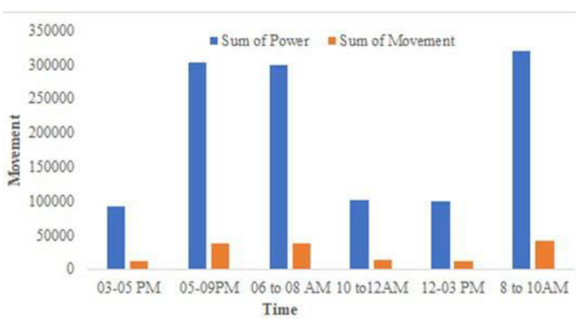
3. Result and discussion:

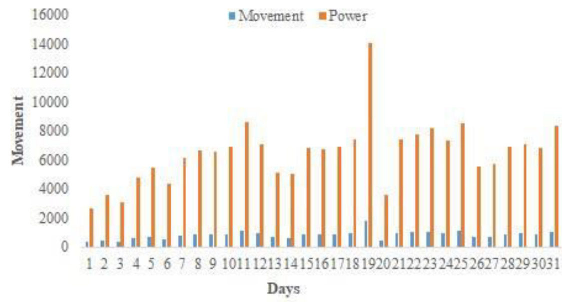
This research demonstrated how to position a developed prototype model on the machine (Treadmill) to maximize power generation. Figure 3 shows the model installed on the machine (Treadmill) for maximum power generation. The treadmill base is the most sensitive area for power generation; hence the tested model was placed there. This research would work well in a variety of situations, such as a dance floor, a railway station, or a stairwell. This model is only suitable for human movement due to sensor limit. The tile has been designed on a 30x30 cm surface area and 36 sensors tested with varying weight of subject as shown in figure 4. The placement of the 12-tile module for power generation should be done according to the dimensions of the treadmill.

The calculated treadmill power analysis for one footstep is 89 W. The estimated cost of installing tiles is 10560 rupees. The treadmill's power analysis was performed at three different speeds: jogging, rapid walking, and slow walking. In this, a person would move at a pace of 2, 3, or mph. As a result, more power is generated as the pace is increased, according to the observation. A calculation of the power at walking pace 2mah for 2000 footsteps yields 178 mW, and at walking pace 3mah for 3000 footsteps, 268 mW. Further, 5mah for 5000 footsteps is equal to 445 mW when jogging. As per the tile effective area of tread mill i.e.,180 cm and 60 cm hence the quantity of tile module calculated i.e. 12.

Optimizing the power using machine learning algorithms Linear regression (LR) using a dataset of experimental analysis as depicted in figure 5. The tile deployment inside the campus was selected using statistical analysis and applying the Linear regression algorithm. The result showed that the placement of tile on the center of the treadmill would be more fruitful for optimizing the power. This optimized power can be used to supply the power to gym equipment so that self-sustained gym equipment can control.

The power analyzed treadmill done for three paces walking slowly, walking fast and jogging. In this the pace of humans would be 2, 3,5 mph. Hence as per the observation while increasing the pace more power generation. In this.





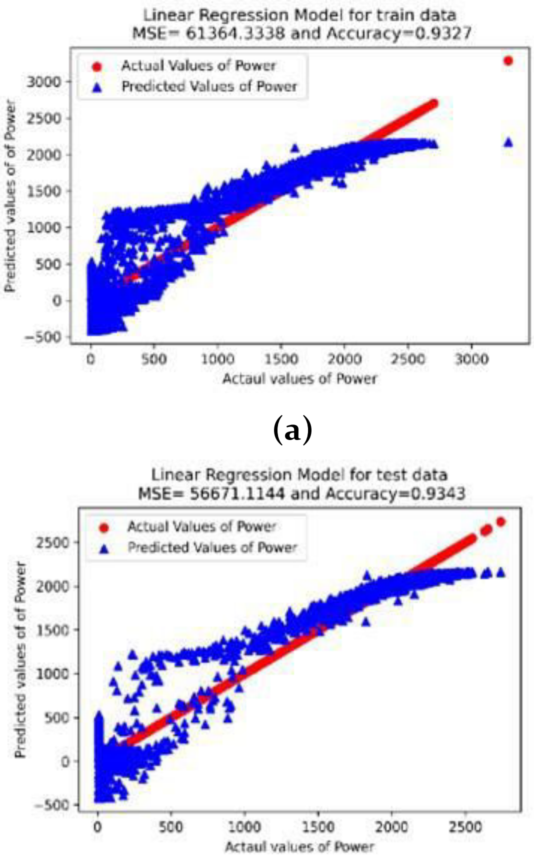
(a) (b)

Figure 4 Mobility pattern of person for (a) Day (b) 6 month

study, developed and assessed machine learning (ML)-based prediction models for PZT tile power optimization. The LR model outperformed the other four ML algorithms in terms of accuracy. The suggested approach can be utilised effectively to forecast power based on sensor quantity and person weight. This model could determine the amount of power generated according to subject weight automatically via treadmill. As a result, the employment of ML algorithms in conjunction with qualitative and thorough information can accurately estimate power according to human weight.

4. Conclusion

The article explored the idea of a self-sustaining treadmill powered by human physical activity.power analysis for varying patterns (like walking, running, and jogging) on machine. The current study aimed to retrospectively develop and validate ML models based on the most relevant features in determining power of PZT tile and the most suitable place for tile deployment on the treadmill This idea can power up the treadmill by calculating the number of calories burned per mile while step-by-step walking on it. The study also included design analysis and power optimisation via the installation of PZT tiles on a treadmill.If we can deploy the model and have a larger number of data specified in the future, our model's performance will improve. Without undergoing any physical tests, it can be employed alongside the other renewable energy producing methods. This study can help to supply the power to the treadmill and other gym equipment while placing the tile on the place where maximum movement of person. Hence this paper successfully presented the finding the suitability of tile deployment on treadmill for optimize power generation.



(a)

(b)

Figure 5: Power prediction using ML algorithm LR (a) Training dataset (b) Testing dataset.

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Conflicts of interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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