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Real Time Gesture Recognition System to Simulate Guitar Chords

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Abstract: We have all been used to buying an instrument in order to practice and learn it. But with the advent of technology, such things are bound to change. Currently, one needs to have an actual guitar to start learning to play it efficiently, and a major investment is involved, which may not be necessary for beginners. In this paper we propose a novel way to utilize the technology available to simulate the feel of playing chords on a guitar, with the use of gesture recognition on a standard laptop webcam as a means for learning guitar chords. This will involve the use of Computer Vision and Machine Learning to train models to detect and track hands, while also using a model with a chord dataset to teach the computer to detect the chord shape presented by the gesture. When making a correct chord shape, the system will ideally detect the chord and play the respective sounds made by the chord.

Keywords: Guitar Chords, Machine Learning, Human Computer Interaction (HCI), Man-Machine Interaction (MMI).

INTRODUCTION

The most aim of hand gesture recognition system is to form a interaction between human and laptop wherever recognized gestures may be used for dominant a automation or conveying meaningful information. How the resulted hand gestures are understood and well interpreted by the computer considered this as the problem of gesture interaction. Human computer interaction (HCI) is also known as Man-Machine Interaction (MMI) which refers to the relation between the human and the computer or machine, and since the machine is insignificant or worthless without suitable utilize by the human. There are two main characteristics should be deemed while designing a HCI system as mentioned functionality and usability. System practically noted the set of functions or services that the system equips to the users whereas system usability noted the amount and scope that the system can operate and perform specific user purposes correctly or efficiently [3].

Primary goal of hand gesture recognition analysis is to form a system which may establish specific human gestures and use them to convey data or for device management. To understand what gestures are given, an examination is required of how other researchers view gestures. How do sociologists and biologists outline and examine "gesture"? How is information encoded in gestures? Also how humans use gestures to communicate with and command other people are explored. Furthermore, engineering researchers have designed a variety of "gesture" recognition systems. People frequently use gestures to communicate. They are used for pointing to a person, to get his attention & convey information about spatial and temporal characteristics. Gesturing does not simply embellish spoken language, but it is part of the language generation process.

EXISTING SYSTEM

Lots of expensive technology like wearable instruments or depth cameras have been used for achieving similar results to this paper, and a few have been listed here.

A. Wearable technology made by Intel and other companies which provide the similar features of this project, but cost a big sum of money for the hardware itself.

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B. Kurv is a wearable touch controller that fits into the palm of one's hands detecting motion, gesture and pressure to feel your intentions.

C. Microsoft Kinect cameras provide motion capture and detection using depth imagery, but again cost a lot of money for the hardware. Similarly,

D. Aerodrums make use of the motion capture technology through the use of a high speed camera along with drum sticks and foot pieces made with reflective materials.

This paper explains the characteristics of a billboard glove, the available programming languages helps a guide to develop an application to communicate with the device and the presentation of data on a screen for further analysis and interpretation on a specific interface and also as a voice message Virtual reality is a computer interface that includes simulation and interactions through different sensory channels in real time, which can be seen, acoustic, tactile, and olfactory stimulus [12]. High prices that will characterize virtual reality devices, has led the search for alternative, less sophisticated as the simulation by conventional computing devices such as keyboard, mouse, and monitor. This is called as desktop virtual reality and the main computer programs can be mentioned VRML (Virtual Reality Modeling Language), Java 3D [3], Direct X, Maya [6], etc. The limitation of these programs made complicated interaction for the user as he had to navigate a three dimensional environment, this became a difficult task, because it must combine the functions of the mouse and keyboard so that it can perform more complex movements like walking forward and turn, or rotate and rise. In the area of technology applied to sign language interpretation will have some significant works. This can be done in two ways, first is to translate the language either spoken or sign language text and the second which means a signer for be translated into spoken or text. In the first case [6], we can cite the work of Fernando Lopez, Javier Tejedor, Daniel Bolaños and José Colas [2], it will develop a text transcript of sign language in the presentation to the end user is performed through an animated character in three dimensions and it can also translate a Web page or a mobile phone to translate a conversation. In the second case [5], that is roofed by this analysis, one amongst the first work is that developed by poet S. Fels and Geoffrey E. Hinton in which a multilayer neural network is used with a VPL glove connected to a DEC talk speech synthesizer so that it makes the system generate audible speech from an input of sign language, this conclude that the system has limitations for using a limited data glove static movements [3]. In 2002,

Disadvantages

Loss navigation and to give alert to If we use GPS, it has poor signals and we fisherman's is not possible. Self-detect and alert system is not implemented, so it is the major drawback of previous system.

PROPOSED SYSTEM

The project is divided into the following three modules:

Detection of Hand

The video recorded using the webcam is done through the use of Open CV on Python, while also displaying the live feed taken from the webcam. The model for the detection of a hand in a video follows Single Shot Multibox Detector (SSD) MobileNetv1 [2][3] architecture implemented directly with Tensor Flow on Python. SSD Mobile Net architecture is chosen due to its speed and reliable results for real time projects. The pre trained weights are taken from the model's training on the Microsoft Common Object in Context (MSCOCO) [4] dataset, and transfer learning is applied by loading these weights to make training faster on our hands dataset. The model is trained on the Oxford Hands Dataset [5] as it contains labelled images of hands in all sorts of positions, making the detection of a hand making any chord shape more efficient in comparison to other hands datasets available. Bounding boxes are applied on the image to mark the region of the hand. The hand detection model works reliably at a distance from the webcam, as the training images contained images of hands at a distance. It starts losing accuracy if the hand is brought close to the webcam, leading to removal of bounding boxes on the screen.

Detection of Chord Shape

The images with the detected hand are cropped to only take the required hand shape. These cropped images are taken and converted into a grayscale image, and thresholding is done to convert it into images with just black or white pixels. This kind of pre-processing is done to make sure the hand is visibly marked irrespective of the skin color complexion of the user, and also to make the size of the images smaller to aid real time processing. The model for detection of chord shapes follows a custom CNN architecture built using Keras with a TensorFlow backend, which takes images of size 50x50 to keep the model as light as possible.

The dataset itself was made by using the hand detector model and OpenCV, through a loop that created 100 images for every chord shape that was necessary for the training process. Each picture was processed with grayscale and thresholding before it is saved, and resized to 150x150 pixels to make manual viewing of the images visible. These images are later downsized further to 50x50 pixels for training. Due to this processing, each file was a meagre 3KB in size, which makes the model light and fit for real time use.

Fig. 1: Example images from the dataset containing A Major, C Major, D Major, E Minor and G Major chords respectively

Layer (type)	Output Shape	Param #
zero_padding2d_1 (ZeroPaddin	(None, 54, 54, 1)	0
conv1_1 (Conv2D)	(None, 50, 50, 8)	208
zero_padding2d_2 (ZeroPaddin	(None, 54, 54, 8)	0
conv1_2 (Conv2D)	(None, 50, 50, 8)	1608
max_pooling2d_1 (MaxPooling2	(None, 25, 25, 8)	0
zero_padding2d_3 (ZeroPaddin	(None, 29, 29, 8)	0
conv2_1 (Conv2D)	(None, 25, 25, 16)	3216
zero_padding2d_4 (ZeroPaddin	(None, 29, 29, 16)	0
conv2_2 (Conv2D)	(None, 25, 25, 16)	6416
max_pooling2d_2 (MaxPooling2	(None, 5, 5, 16)	0
zero_padding2d_5 (ZeroPaddin	(None, 9, 9, 16)	0
conv3_1 (Conv2D)	(None, 5, 5, 40)	16040
zero_padding2d_6 (ZeroPaddin	(None, 9, 9, 40)	0
conv3_2 (Conv2D)	(None, 5, 5, 32)	32032
dropout_1 (Dropout)	(None, 5, 5, 32)	0
flatten_1 (Flatten)	(None, 800)	0
dense_1 (Dense)	(None, 512)	410112
activation_1 (Activation)	(None, 512)	0
dropout_2 (Dropout)	(None, 512)	0
dense_2 (Dense)	(None, 512)	262656
activation_2 (Activation)	(None, 512)	0
dropout_3 (Dropout)	(None, 512)	0
dense_3 (Dense)	(None, 512)	262656
activation_3 (Activation)	(None, 512)	0
dropout_4 (Dropout)	(None, 512)	0
dense_4 (Dense)	(None, 512)	262656
activation_4 (Activation)	(None, 512)	0
dense_5 (Dense)	(None, 512)	262656
activation_5 (Activation)	(None, 512)	0
dense_6 (Dense)	(None, 512)	262656
activation_6 (Activation)	(None, 512)	0
dense_7 (Dense)	(None, 512)	262656
activation_7 (Activation)	(None, 512)	0
dense_8 (Dense)	(None, 512)	262656
activation_8 (Activation)	(None, 512)	0
dense_9 (Dense)	(None, 5)	2565
activation_9 (Activation)	(None, 5)	0

Total params: 2,310,789
Trainable params: 2,310,789
Non-trainable params: 0

Fig. 2: Summary of the custom model made using Keras

Integration Module - Combining the two models

The inference graph from the hand detection model is loaded and the video feed from the webcam is fed to the model, while the chord shape recognition model and the corresponding weights of the same are also loaded in parallel and kept ready for processing. The input image from the webcam is fed to the first hand detection model, which uses the SSD concept to reliably find the position of the hand if it exists. If the hand exists, it is cropped out and pre-processed and used for prediction. This allows the two models to be integrated and work together to arrive at the required conclusion of the chord shape shown to the webcam.

The cropped region is processed in the same way as the dataset was made to yield images containing only black and white pixels. These images are then resized to 50x50 pixels and fed to the trained model, which predicts the probability of each class (the chords) and returns an array of the same. The class with over 90% probability is taken and the corresponding chord is played through an audio file containing the chord's sound by using the PyGame library on Python. This music keeps playing till a new chord is shown to the webcam, or until the hand is removed from the screen. Depending on the chord shape, the application also shows the name of the chord being played at the current moment on the screen. This application runs irrespective of the user, i.e, skin complexion, size of the hand and the background behind the hand do not alter the output in any way, as the datasets are diverse enough and the pre-processing done remove these factors from consideration for all of these possible issues.

BLOCK DIAGRAM

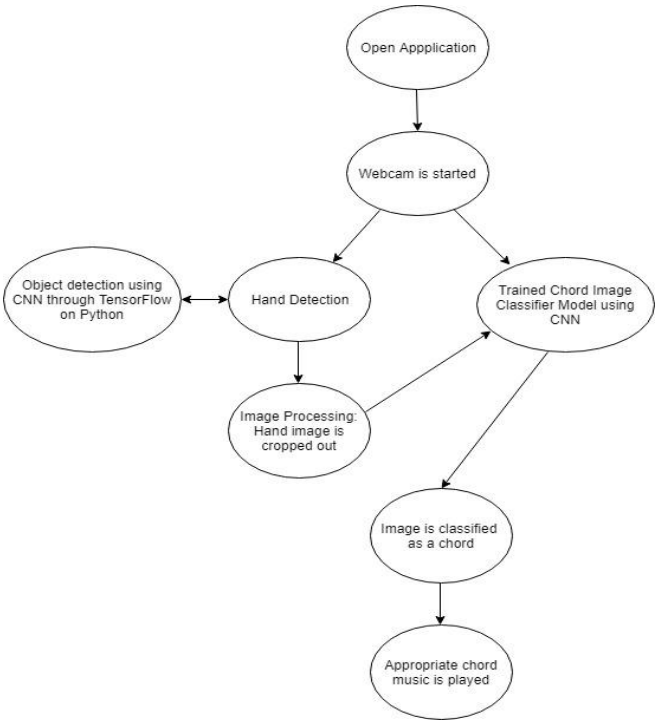

Fig. 3: Flowchart consisting of the steps involved in the project

EXPERIMENTAL SETUP

- Pre-processing:
- Detection:
- Segmentation:
- Recognition

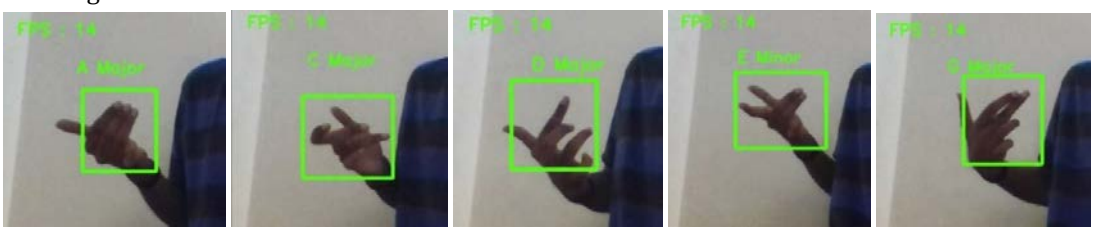

Fig. 4: A Major, C Major, D Major, E Minor and G Major chords detected by the application

Installing Python

Here is a quick overview of installing Python on various platforms:

- Open a Web browser and go to https://www.python.org/downloads/.

Running Python

$python # Unix/Linux

or

python% # Unix/Linux

or

C:> python # Windows/DOS

Sr. No.	Option & Description
1	**-d** It provides debug output.
2	**-O** It generates optimized bytecode (resulting in .pyo files).
3	**-S** Do not run import site to look for Python paths on startup.
4	**-v** Verbose output (detailed trace on import statements).
5	**-X** Disable class-based built-in exceptions (just use strings); obsolete starting with version 1.6.
6	**-c cmd** run Python script sent in as cmd string
7	**File** run Python script from given file

SYSTEM CONFIGURATIONS

Software Requirements

- OS : Windows 7
- Technology : python
- Web Technologies : Html, JavaScript, CSS
- IDE : Netbeans
- Web Server : Tomcat
- Database : My SQL
- Java Version : J2SDK1.5

Hardware Requirements

- Hardware : Pentium Dual Core
- Speed : 2.80 GHz
- RAM : 4GB
- Hard Disk : 500 GB
- Key Board : Standard windows keyboard
- Mouse : Two or Three Button Mouse
- Monitor : SVGA

CONCLUSION

The proposed application in this paper works efficiently to simulate guitar chords in real time with the use of two separate CNN models, one being SSD MobileNet v1 for hand tracking and the other being a custom gesture recognition model built using Keras. These two models work with each other to detect the hand and the chord shape made by it, and plays the appropriate music for the given chord. The application on the whole performs accurately as expected, with occasional mistakes on hand detection and wrong chord shape classification. This gesture recognition system can very well be used in real time and on the go anywhere in the world, as long as the webcam functions well with good lighting in the background.

REFERENCES

[1] Krishnamoorthy, P., & Jayalakshmi, T. (2012). Preparation, characterization and synthesis of silver nanoparticles by using phyllanthusniruri for the antimicrobial activity and cytotoxic effects, *Journal of Chemical and Pharmaceutical Research, 4*(11), 4783-4794.

[2] Amir, M., Gungunes, H., Slimani, Y., Tashkandi, N., El Sayed, H.S., Aldakheel, F., Sertkol, M., Sozeri H., Manikandan A., Ercan, I., & Baykal, A. (2019). Mössbauer studies and magnetic properties of cubic CuFe 2 O 4 nanoparticles. *Journal of Superconductivity and Novel Magnetism*, *32*(3), 557-564.

[3] Raj, M.S., Saravanan T., & Srinivasan, V. (2014). A modified direct torque control of induction motor using space vector modulation technique. *Middle - East Journal of Scientific Research, 20*(11), 1572-1574.

[4] Khanaa, V., & Thooyamani, K.P. (2013). Using triangular shaped stepped impedance resonators design of compact microstrip quad-band. *Middle-East Journal of Scientific Research*, *18*(12), 1842-1844.

[5] Asiri S., Sertkol M., Güngüneş H., Amir M., Manikandan A., Ercan I., & Baykal A. (2018). The Temperature Effect on Magnetic Properties of NiFe 2 O 4 Nanoparticles. *Journal of Inorganic and Organometallic Polymers and Materials, 28*(4), 1587-1597.

[6] Thaya, R., Malaikozhundan, B., Vijayakumar, S., Sivakamavalli, J., Jeyasekar, R., Shanthi, S., Vaseeharan, B., Ramasamy, P., & Sonawane, A. (2016). Chitosan coated Ag/ZnO nanocomposite and their antibiofilm, antifungal and cytotoxic effects on murine macrophages. *Microbial pathogenesis*, *100*, 124-132.

[7] Kolanthai, E., Ganesan, K., Epple, M., & Kalkura, S.N. (2016). Synthesis of nanosized hydroxyapatite/agarose powders for bone filler and drug delivery application. *Materials Today Communications*, *8*, 31-40.

[8] Thilagavathi, P., Manikandan, A., Sujatha, S., Jaganathan, S.K., & Arul Antony, S. (2016). Sol–Gel Synthesis and Characterization Studies of NiMoO4 Nanostructures for Photocatalytic Degradation of Methylene Blue Dye. *Nanoscience and Nanotechnology Letters*, *8*(5), 438-443.

[9] Thamotharan C., Prabhakar S., Vanangamudi, S., & Anbazhagan, R. (2014). Anti-lock braking system in two wheelers. *Middle - East Journal of Scientific Research, 20*(12), 2274-2278.

[10] Thamotharan C., Prabhakar S., Vanangamudi, S., Anbazhagan, R., & Coomarasamy C. (2014). Hydraulic rear drum brake system in two wheeler. *Middle - East Journal of Scientific Research, 20*(12), 1826-1833.

[11] Vanangamudi, S., Prabhakar S., Thamotharan C., & Anbazhagan, R. (2014). Collision control system in cars. *Middle - East Journal of Scientific Research, 20*(12), 1799-1809.

[12] Vanangamudi S., Prabhakar S., Thamotharan C., & Anbazhagan R. (2014). Drive shaft mechanism in motor cycle. *Middle - East Journal of Scientific Research, 20*(12), 1810-1815.

[13] Anbazhagan R., Prabhakar S., Vanangamudi S., & Thamotharan C. (2014). Electromagnetic engine. *Middle - East Journal of Scientific Research, 20*(3), 385-387, 2014.

[14] Kalaiselvi, V.S., Prabhu, K., & Mani Ramesh, V.V. (2013). The association of serum osteocalcin with the bone mineral density in post-menopausal women. *Journal of clinical and diagnostic research: JCDR*, *7*(5), 814-816.

[15] Kalaiselvi, V.S., Saikumar, P., & Prabhu, K. (2012). The anti mullerian hormone-a novel marker for assessing the ovarian reserve in women with regular menstrual cycles. *Journal of clinical and diagnostic research: JCDR*, *6*(10), 1636-1639.

[16] Arul, K.T, Manikandan, E., Ladchumananandasivam, R., & Maaza, M. (2016). Novel polyvinyl alcohol polymer based nanostructure with ferrites co-doped with nickel and cobalt ions for magneto-sensor application. *Polymer International*, *65*(12), 1482-1485.

[17] Das, M.P., & Kumar, S. (2015). An approach to low-density polyethylene biodegradation by Bacillus amyloliquefaciens. *3 Biotech*, *5*(1), 81-86.

[18] Vanangamudi S., Prabhakar S., Thamotharan C., & Anbazhagan, R. (2014). Turbo charger in two wheeler engine. *Middle - East Journal of Scientific Research, 20*(12), 1841-1847.

[19] Vanangamudi S., Prabhakar S., Thamotharan C., & Anbazhagan, R. (2014). Design and calculation with fabrication of an aero hydraulwicclutch. *Middle - East Journal of Scientific Research, 20*(12), 1796-1798, 2014.

[20] Saravanan, T., Raj, M.S., & Gopalakrishnan, K. (2014). VLSI based 1-D ICT processor for image coding. *Middle-East Journal of Scientific Research*, *20*(11), 1511-1516.

[21] Ajona, M., & Kaviya, B. (2014). An environmental friendly self-healing microbial concrete. *International Journal of Applied Engineering Research*, *9*(22), 5457-5462.

[22] Hemalatha, R., & Anbuselvi, S. (2013). Physicochemical constituents of pineapple pulp and waste. *Journal of Chemical and Pharmaceutical Research*, *5*(2), 240-242.

[23] Langeswaran, K., Revathy, R., Kumar, S.G., Vijayaprakash, S., & Balasubramanian, M.P. (2012). Kaempferol ameliorates aflatoxin B1 (AFB1) induced hepatocellular carcinoma through modifying metabolizing enzymes, membrane bound ATPases and mitochondrial TCA cycle enzymes. *Asian Pacific Journal of Tropical Biomedicine*, *2*(3), S1653-S1659.

[24] Masthan, K.M.K., Babu, N.A., Dash, K.C., & Elumalai, M. (2012). Advanced diagnostic aids in oral cancer. *Asian Pacific Journal of Cancer Prevention*, *13*(8), 3573-3576.

[25] Asiri S., Güner S., Demir A., Yildiz A., Manikandan A., & Baykal, A. (2018). Synthesis and Magnetic Characterization of Cu Substituted Barium Hexaferrites. *Journal of Inorganic and Organometallic Polymers and Materials,* 28(3), 1065-1071.

[26] Vellayappan, M.V., Jaganathan, S.K., & Manikandan, A. (2016). Nanomaterials as a game changer in the management and treatment of diabetic foot ulcers. *RSC Advances*, *6*(115), 114859-114878.

[27] Vellayappan, M.V., Venugopal, J.R., Ramakrishna, S., Ray, S., Ismail, A.F., Mandal, M., Manikandan, A., Seal, S., & Jaganathan, S.K. (2016). Electrospinning applications from diagnosis to treatment of diabetes. *RSC Advances*, *6*(87), 83638-83655.

[28] Bavitra, K., Sinthuja, S., Manoharan, N., & Rajesh, S. (2015). The high efficiency renewable PV inverter topology. *Indian Journal of Science and Technology*, *8*(14), 1.

[29] Vanangamudi, S., Prabhakar, S., Thamotharan, C., & Anbazhagan, R. (2014). Design and fabrication of dual clutch. *Middle-East Journal of Scientific Research*, *20*(12), 1816-1818.

[30] Sandhiya, K., & Kaviya, B. Safe bus stop location in Trichy city by using gis. *International Journal of Applied Engineering Research*, *9*(22), 5686-5691.

[31] Selva Kumar, S., Ram Krishna Rao, M., Deepak Kumar, R., Panwar, S., & Prasad, C.S. (2013). Biocontrol by plant growth promoting rhizobacteria against black scurf and stem canker disease of potato caused by Rhizoctonia solani. *Archives of Phytopathology and Plant Protection*, *46*(4), 487-502.

[32] Sharmila, S., & Jeyanthi Rebecca, L. (2012). GC-MS Analysis of esters of fatty acid present in biodiesel produced from Cladophora vagabunda. *Journal of Chemical and Pharmaceutical Research*, *4*(11), 4883-4887.

[33] Ramkumar, M., Rajasankar, S., Gobi, V.V., Dhanalakshmi, C., Manivasagam, T., Thenmozhi, A.J., Essa, M.M., Kalandar, A., & Chidambaram, R. (2017). Neuro protective effect of Demethoxycurcumin, a natural derivative of Curcumin on rotenone induced neurotoxicity in SH-SY 5Y Neuroblastoma cells. *BMC complementary and alternative medicine*, *17*(1), 217.

[34] Selvi, S.A., & Sundararajan, M. (2016). A Combined Framework for Routing and Channel Allocation for Dynamic Spectrum Sharing using Cognitive Radio. *International Journal of Applied Engineering Research*, *11*(7), 4951-4953.

[35] Krupaa R.J., Sankari S.L., Masthan K.M.K., & Rajesh E. (2015). Oral lichen planus: An overview. *Journal of Pharmacy and Bioallied Sciences, 7,* S158-S161.

[36] Srividya, T., & Saritha, B. (2014). Strengthening on RC beam elements with GFRP under flexure. *International Journal of Applied Engineering Research*, *9*(22), 5443-5446.

[37] Kumar, J., Sathish Kumar, K., & Dayakar, P. (2014). Effect of microsilica on high strength concrete. *International Journal of Applied Engineering Research*, *9*(22), 5427-5432.

[38] Saraswathy, R., & Saritha, B. (2014). Planning of integrated satellite township at Thirumazhisai. *International Journal of Applied Engineering Research*, *9*(22), 5558-5560.

[39] Saritha, B., Ilayaraja, K., & Eqyaabal, Z. (2014). Geo textiles and geo synthetics for soil reinforcement. *International Journal of Applied Engineering Research*, *9*(22), 5533-5536.

[40] Iyappan, L., & Dayakar, P. (2014). Identification of landslide prone zone for coonoor taluk using spatial technology. *International Journal of Applied Engineering Research*, *9*(22), 5724-5732.

[41] Moradi, H., Namdaran, T., Gooran, P.R., Pouradad, E., & Aivazie, M.R. (2015). Design and Analysis of Equivalent Circuit Model Laser VSCEL Parameters Using Photonics. *International Academic Journal of Innovative Research, 2*(8), 20-37.

[42] Ramahrishnan, S., Geetha, B.E.R., & P. Vasuki, (2014). Image Encryption Using Chaotic Maps in Hybrid Domain. *International Journal of Communication and Computer Technologies, 2*(2), 74-78.

[43] Silvia Priscila, S., & Dr.Hemalatha, M. (2018). Heart Disease Prediction Using Integer-Coded Genetic Algorithm (ICGA) Based Particle Clonal Neural Network (ICGA-PCNN). *Bonfring International Journal of Industrial Engineering and Management Science, 8*(2), 15TO19.

[44] Sharifzadeh, M. (2015). The Survey of Artificial Neural Networks-Based Intrusion Detection Systems. *International Academic Journal of Science and Engineering, 2*(4), 11-18.

[45] Rajavenkatesan, T., Mohanasundaram, C., Ajith, A.S., & Vignesh, P. (2017). Photo Voltaic Cooling Can. *International Journal of Communication and Computer Technologies, 5*(1), 17-22.

[46] Gowshika, E., & Sivakumar, S. (2017). Smart LPG Monitoring and Controlling System. *International Journal of Communication and Computer Technologies, 5*(1), 23-26.

[47] Soorya, B., Shamini, S.S., & Sangeetha, K. (2017). VLSI Implementation of Lossless Video Compression Technique Using New Cross Diamond Search Algorithm. *International Journal of Communication and Computer Technologies, 5*(1), 27-31.

[48] Cheriyan, J.E., SatheesBabu, S., & Balasubadra, K. (2014). Efficient Filtering and Location Detection against Insider Attacks in WSN. *International Journal of System Design and Information Processing, 2*(1), 19-22.

[49] Dr.Balasubramaniam, P.M., Preethi, S., Surya Prakash, K., Swathi, S., & Vishnu, B. (2019). Implementation of Advanced Solar Tracking and Cleaning to Improve Efficiency. *Bonfring International Journal of Networking Technologies and Applications, 6*(1), 1-5.

[50] Daund, A., Mahishi, S., & Berde, N. (2014). Synchronization of Parallel Dual Inverted Pendulums using Optimal Control Theory. *The SIJ Transactions on Advances in Space Research & Earth Exploration, 2*(2), 7-11.

[51] Rinsha, V., Varghese, J.M., and Dr.Shahin, M. (2014). A Grid Connected Three-Port Solar Micro Inverter. *Bonfring International Journal of Power Systems and Integrated Circuits, 4*(2), 25-30.

[52] Rugminidevi, G. (2014). MIMO Sonar and SIMO Sonar: A Comparison. *International Scientific Journal on Science Engineering & Technology, 17*(9), 873-881.