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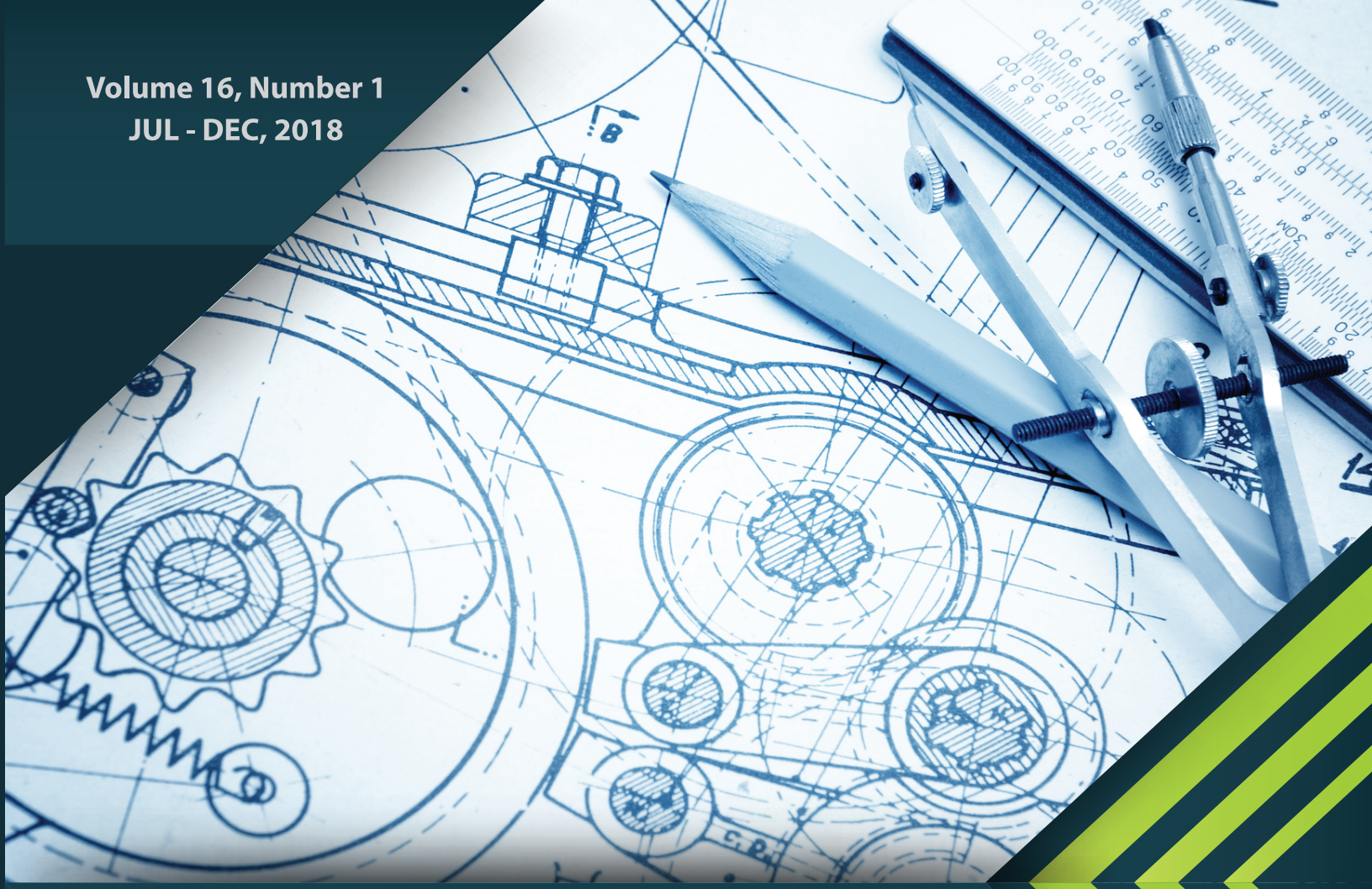

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CONTENTS

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Application of Fuzzy Logic Control for Performance Analysis of Transmission System Using Unified Power Flow Controller

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Abstract

The load demand in power systems is increasing exponentially, making it difficult for the existing power system networks to meet targets due to scarcity of resources. To address this issue, this paper proposes a unified power flow controller application to meet the increased load demand in the existing power system networks. The proposed technique uses a Fuzzy Logic Controller (FLC) as an intelligent tool to overcome the limitations of the existing UPFC controller under varying operating conditions. The UPFC shunt and series controllers based on FLC are developed as a stand-alone module in PSCAD software. The proposed FLC based UPFC is tested using IEEE-14 bus system with various test cases and compared with the exiting Proportional-Integral (PI) controller based UPFC to demonstrate its effectiveness. Our results show that the proposed FLC successfully improves the performance of UPFC by enhancing the active power flow. In addition, it further reduces the reactive power and improves the voltage profile.

Keywords—Fuzzy logic controller, flexible alternating current transmission, PI controller, unified power flow controller.

1 Introduction

In interconnected networks, utilities can draw power from generator reserves of different areas to build up the reliability of the power system. However, large interconnected networks may encounter instability conditions such as voltage or frequency instability and line overloading which may lead to a large number of blackouts in different areas [1]. One way to overcome these problems is the installation of new transmission lines in order to enhance the reliability of the interconnected power system [2]. However, the problems of finite energy sources, climate restraint, capital and time needed to construct new transmission systems have compelled the researchers to look for other options to boost the power system ability within the existing transmission systems. Among these options, Flexible Alternating Current Transmission System (FACTS) devices have gained popularity as a mean to increase the performance of already existing transmission networks [3].

UPFC has the capacity of offering support together or selectivity for regulation phase angle, voltage series compensation, voltage regulation, and control of power flow individually transferred over the line [4] [5]. When reactive power flow changes in transmission system, it affects the UPFC bus voltage and other parameters. This is one of the dedicated challenges of UPFC for power control [6]. The UPFC comprises of a STATCOM associated consecutive over DC interface capacitor and static synchronous series compensator (SSSC) as shown in Figure 1. The SSSC is a manageable voltage source, while the STATCOM acts as a controllable current source [7] [8]. A three-phase transformer is used to connect STATCOM with AC system network which predominantly creates the real power for the

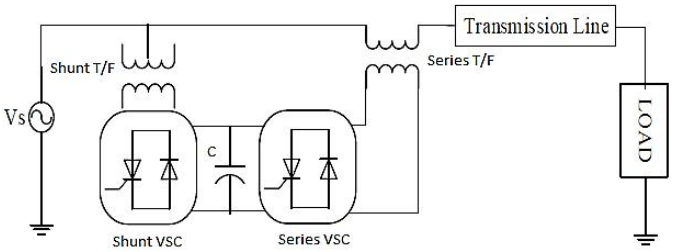

Fig. 1: Circuit Diagram of UPFC

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consumption of SSSC. Furthermore, the STATCOM helps the transmission network in order to compensate the reactive power. The SSSC recovers voltage drops in the power line by infusing AC voltage of controllable phase and magnitude, thus enhancing reactive and active power transmission. Reactive power can be swapped by both the converters autonomously at the terminals [9] [10].

Existing conventional UPFC controllers employ Proportional-Integral (PI) controllers which may not be suitable due to the transient nature of power system. It is because PI controllers encounter problem in their parameters tuning. Incorrect tuning of PI parameters may cause failure during frequency oscillation, overloading and transient conditions [11] [12]. Some solutions have been proposed to improve the tuning of PI controllers such as particle swarm optimization (PSO) technique [13]. It has been observed that with the use of PSO technique, the response of PI controller is improved. However, it also increases the complexity of the system. To address this issue, this paper considers the application of the fuzzy logic control as a suitable option.

2 Methodology

In this section, modelling of UPFC with its main parts such as series and shunt converters in PSCAD/EMTDC software is presented. It is further followed by the modelling of control strategies for both series and shunt controllers of UPFC based on PI controller. Furthermore, the development of FLC based UPFC in PSCAD/EMTDC software is also discussed. Finally, the UPFC shunt and series controller parameters in IEEE-14 bus system are presented for both FLC and PI controllers.

2.1 Modeling of UPFC in PSCAD/EMTDC

The proposed UPFC model and test system are designed in PSCAD/EMTDC software version 4.2.1. The UPFC model designed in PSCAD/EMTDC is shown in Figure 2. Two generators are installed at both ends of the transmission line. Series and shunt transformers are used to link UPFC with the power network. UPFC comprises of two VSC's which are connected by means of DC link capacitor. STATCOM is a shunt VSC and SSSC is series VSC. Each converter is built as a three-phase, six-pulse controlled bridge. Switching devices for both converters can be made from IGBTs with anti-parallel diodes.

2.1.1 Modeling of Shunt Converter

Shunt converter is a three-phase six-pulse VSC, built using six IGBT switches coupled in a bridge configuration as shown in Figure 2. The IGBT is considered as a self-commutating component that enables the bi-directional operation of the UPFC. Thus, UPFC can provide the real power exchange between both converters as well as to generate or absorb the reactive power at the AC sides of both converters independently. Among different power switches, IGBT is chosen to build the UPFC converters due to its ability to deal with higher power rating and speed switching compared to other power switches [14]- [16].

The available IGBT block in PSCAD software is modelled without anti-parallel diode. Therefore, the anti-parallel diode should be added in parallel with IGBT model in PSCAD software to enable the bi-directional operation of the UPFC. A snubber circuit is connected in parallel with each IGBT to overcome the transient voltage across IGBT during the switching operation. A snubber circuit consists of a series resistor (500 ohm) and capacitor (0.1 pF) connected in parallel across IGBT [16]. Low-pass LC filter is connected in each phase of the shunt converter in order to block the harmonics developed due to switching operation. A three-phase shunt transformer is used to connect the shunt converter with the transmission line in order to provide segregation and altering current or voltage levels. It avoids a DC link capacitor being shorted because of switching operation of different devices.

2.1.2 Modeling of Series Converter

The modeling of a series converter is similar to the shunt converter design as shown in Figure 2. The series converter consists of a full-bridge, three-phase, six-pulse converter. IGBT switches with anti-parallel diodes and snubber circuits are chosen to build the series converter. The rating of the IGBTs is chosen as the same as that of the shunt converter IGBTs.

In order to eliminate the current harmonics produced due to the switching operation, low-pass filters are used in each phase. The series converter is linked with transmission line via three single phase series transformers while the turn's ratio is 1/1.

The design process of the UPFC includes the selection of the shunt and series transformer ratings, filter circuits and DC link capacitor rating. To find out losses in the whole system before installation of the UPFC, it is necessary to know the parameters of the power network for the initial test. The parameters of the DC link capacitor, low-pass filter, shunt and series transformers for IEEE-14 test system are mentioned in Table 1 [17].

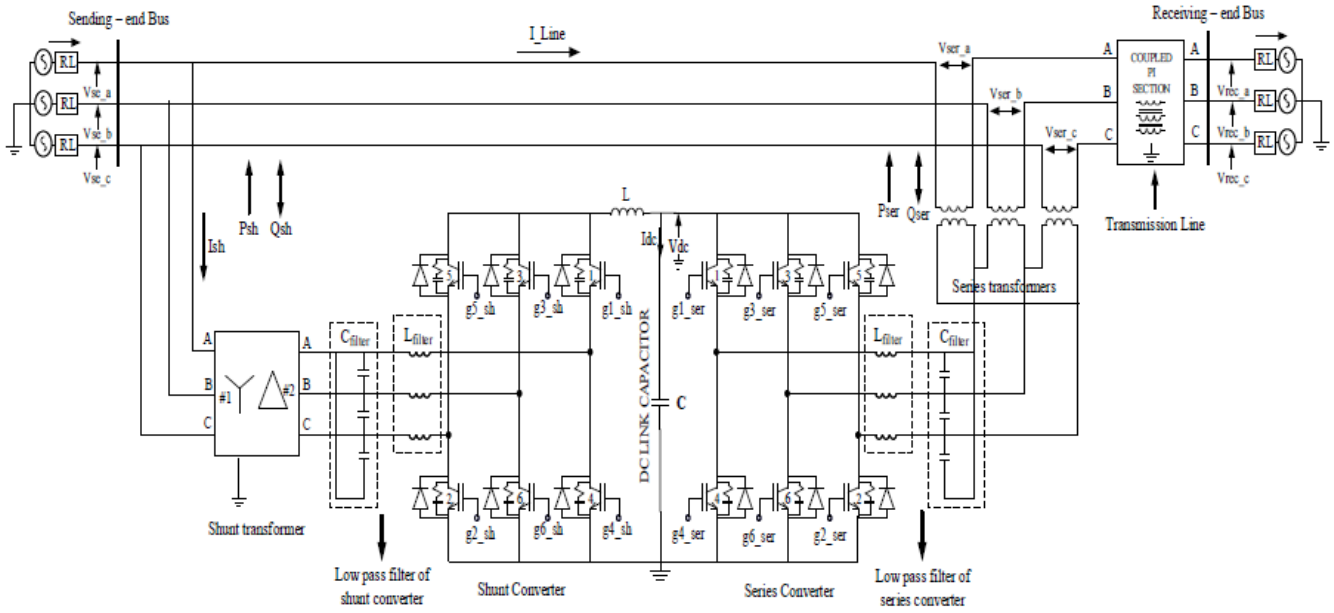

Fig. 2: UPFC model designed in PSCAD/EMTDC software

TABLE 1: Shunt and series converter parameter

UPFC Location Across LINE 9-14	
Shunt transformer	Three Phase Y/Δ coupling transformer Transformer Capacity: 100MVA Line Voltage (RMS): 138 kV/33 kV Leakage Reactance: 0.1 pu Air Core Reactance: 0.2 pu
Low Pass Filter of Shunt Converter	Capacitance: $95\mu F$ Inductance : 0.05 H
Series transformer	Three Phase isolation transformer Transformer Capacity: 25MVA Line Voltage (RMS): 14.33 kV/14.33 kV Leakage Reactance: 0.1 pu Air Core Reactance: 0.2 pu
Low Pass filter of Series Converter	Capacitance: $165\mu F$ Inductance : 0.04 H
DC Link Capacitance	$1600\mu F$

2.2 Modeling of Series and Shunt Controllers

The following sections explain the modeling of series and shunt controllers.

2.2.1 UPFC Shunt and Series Converter Control Strategies Based on PI Controller

Figure 3 shows the flow chart for power flow control by PI based UPFC. The operation of the shunt and series controller depends on the UPFC mode of operation. The shunt converter mode of the operation is chosen as an automatic voltage control. Whereas, the series converter mode of the operation is chosen as a power flow control. In this section, the design of both controllers of UPFC based on PI and fuzzy controller is presented. Both the controllers are implemented using PSCAD/EMTDC software.

Figure 4 shows the PI controller based mechanism for DC link. Whereas, Figure 5 shows the SPWM procedure for UPFC shunt converter [18]. The switching signals can be acquired from SPWM techniques. The magnitude shunt inserted voltage ($Vmag\_sh$) can be used as the magnitude of reference sine wave. The carrier signal having 4.5 kHz frequency is compared with the reference signal in SPWM technique in order to generate firing signals ($g1\_sh, g4\_sh, g3\_sh, g6\_sh, g5\_sh$ and $g2\_sh$) for IGBT switches of shunt converter [19].

The control procedure of series controller of UPFC developed in PSCAD/EMTDC environment is shown in Figure 6. Following equations are used to compute

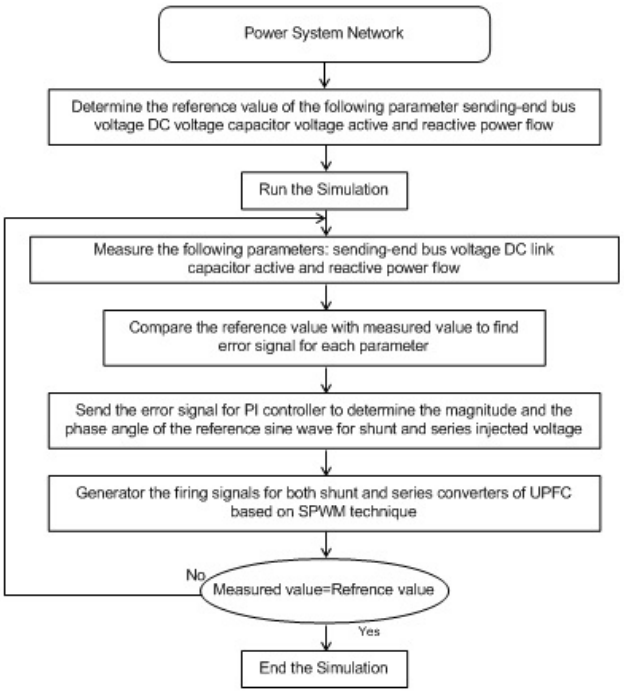

Fig. 3: Flowchart of PI controller based UPFC

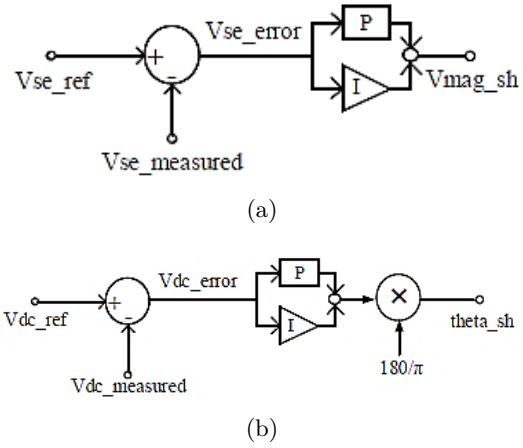

Fig. 4: PI controller mechanism for DC link and sending voltage

the series magnitude and phase angle [17]:

$$V_{mag\_ser} = \sqrt{V_d^2 - V_q^2} \tag{1}$$

$$theta\_{ser} = tan^{-1}\frac{V_q}{V_d} \tag{2}$$

Similar to the shunt in series controller, the process of switching signal generation is also conducted using SPWM technique. The mechanism for providing the switching signals for SPWM technique for series converter, IGBT switch is shown in Figure 7. The output signals of the SPWM are provided as switching firing

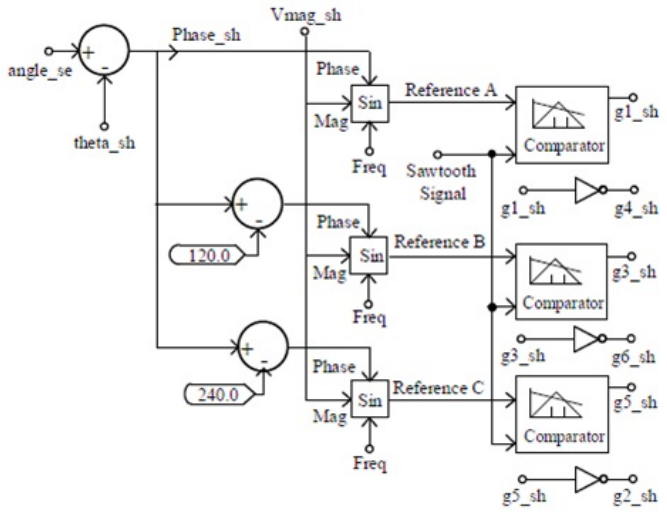

Fig. 5: Mechanism of SPWM technique for shunt converter

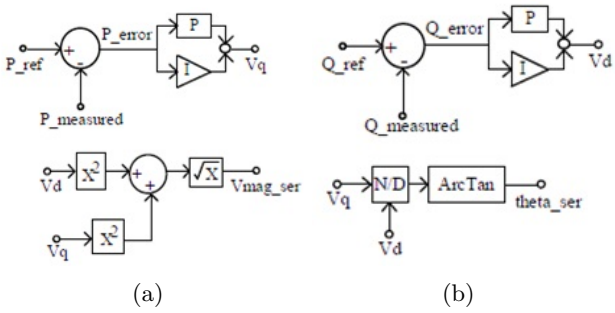

Fig. 6: PI controller for P and Q power flow

signals $g1\_ser$, $g4\_ser$, $g3\_ser$, $g6\_ser$, $g5\_ser$ and $g2\_ser$ for the series converter IGBT switches.

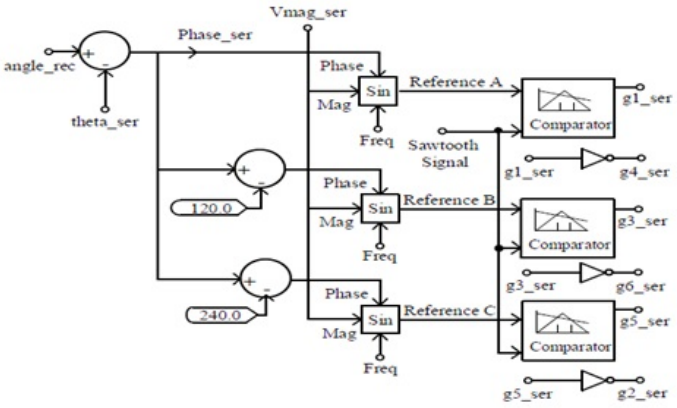

Fig. 7: Mechanism of SPWM technique for series converter

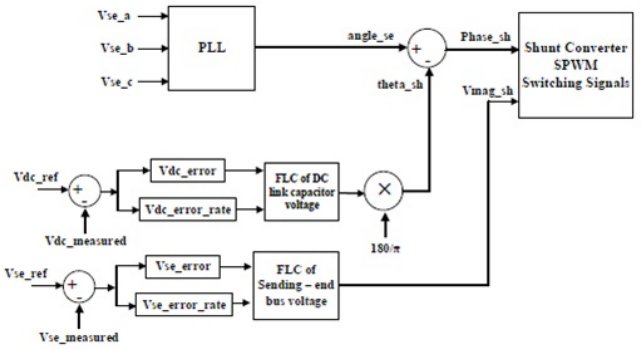

Fig. 8: Mechanism of SPWM technique for series converter

2.2.2 *UPFC Shunt and Series Converter Control Strategies Based on Fuzzy Logic Controller*

The control method for PI based shunt and series UPFC converters has been discussed in the preceding section. However, PI controller does not guarantee the fast response with minimum output of the UPFC due to some limitations. The main limitation of PI controller is its difficulty in tuning its parameters (K_p, K_i) in transient systems and sub-optimal performance in the nonlinear systems. To address this issue, we proposes a FLC based UPFC. FLC is able of tackling complicated control problems whose system behaviour has large uncertainties and is not well understood. FLC is more robust and has many advantages over traditional PI controller because it doesn't require any exact mathematical model of the system and can give quick reaction with least control signals during rapid changing conditions of the power system [20]. Furthermore, FLC possesses robustness to control the power system parameters under varying operating conditions. The shunt converter control mechanism based on the fuzzy logic designed in PSCAD/EMTDC is displayed in Figure 8 and 9. The difference of $V_{se\_measured}$ and reference value V_{se_ref} is used to produce the error signal of sending-end voltage. Magnitude of inserted shunt voltage V_{mag_sh} can be taken from another FLC with input error signal V_{se_error} and error rate $V_{se\_error\_rate}$. The rest of the procedure to produce the SPWM switching signals is similar to the control strategy for shunt converter based on PI controller which is explained in section 2.2.1.

PSCAD/EMTDC software is used to build fuzzy logic control design of series converter given in Figure 10-11. In order to control the active power flow, $P\_measured$ is measured and compared to the reference active power flow P_ref. The error signals P_error and P_error_rate can pass through FLC

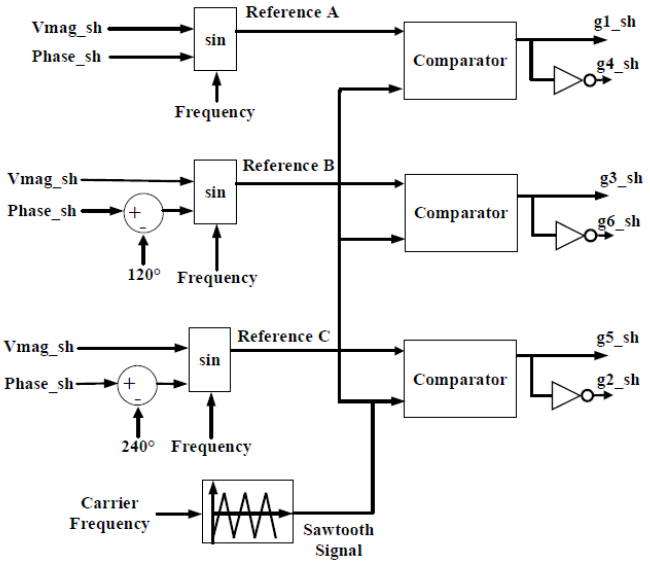

Fig. 9: Mechanism of SPWM technique for series converter

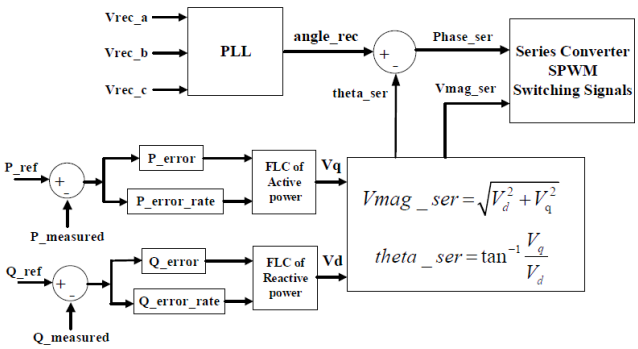

Fig. 10: FLC of the P and Q power flow

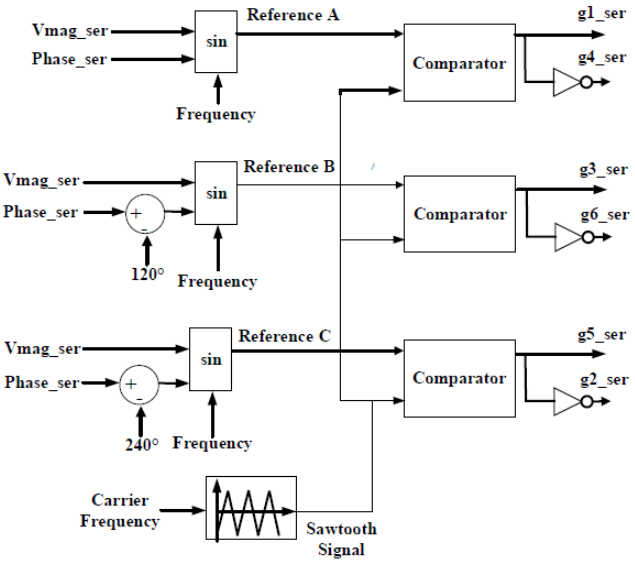

Fig. 11: SPWM technique to generate firing signals for series converter of UPFC

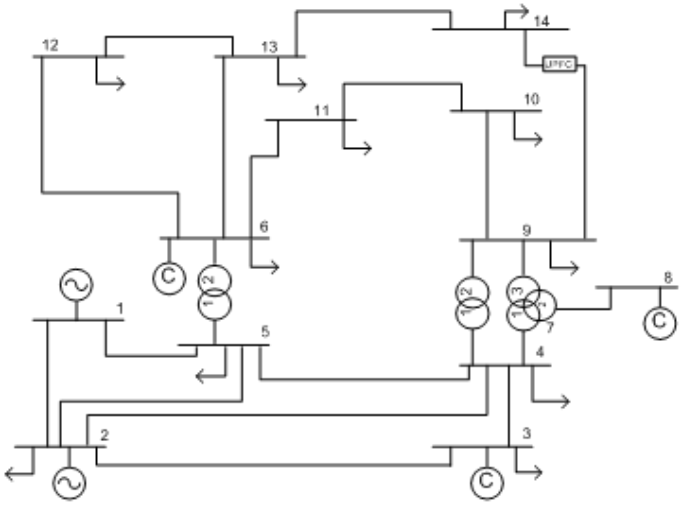

Fig. 12: IEEE-14 Bus System

block to create series injected voltage quadrature component V_q.

2.3 Modeling of Test System and Proposed Fuzzy Controller

IEEE-14 bus is used as a test system designed in PSCAD software for the simulation before and after the installation of UPFC. Out of 14 buses, Bus 2 and 1 are generator buses (PV buses) of the test system and buses 8, 6, 3 are connected with synchronous condensers to furnish reactive power support to network. The remaining 11 buses are load buses.

This study employs 138 kV and 100 MVA as the base values. In order to know the optimal region of UPFC in IEEE-14 bus network, Voltage Collapse Point Indicators (VCPI) and line stability factor (LQP) stability indices are used in the same way as discussed in [21]. The value of LQP or VCP indices are monitored to remain below 1.0 in the transmission network by adding all PQ loads at all buses by specific percentages. The line whose index value exceeds 1.0 is considered as unstable and also the location for UPFC placement. The same procedure is implemented for IEEE-14 bus network and it is found that the index value for line 9-14 reaches 1.0 [22]. Thus, the optimal location of the proposed UPFC is line 9-14 in IEEE-14 bus network, as shown in Figure 12. The Takagi-Sugeno fuzzy inference system module is designed in MATLAB whereas IEEE-14 bus test system are modelled in PSCAD. FLC based UPFC is installed across lines 9-14 whose membership functions are shown in Figure 13. Figure 13(a) shows the membership functions for input error of reactive power (Q), active power (P), V_{dc} and V_{se}. The membership functions of ($error\_rate$) are illustrated in Figure 13(b) in which the output

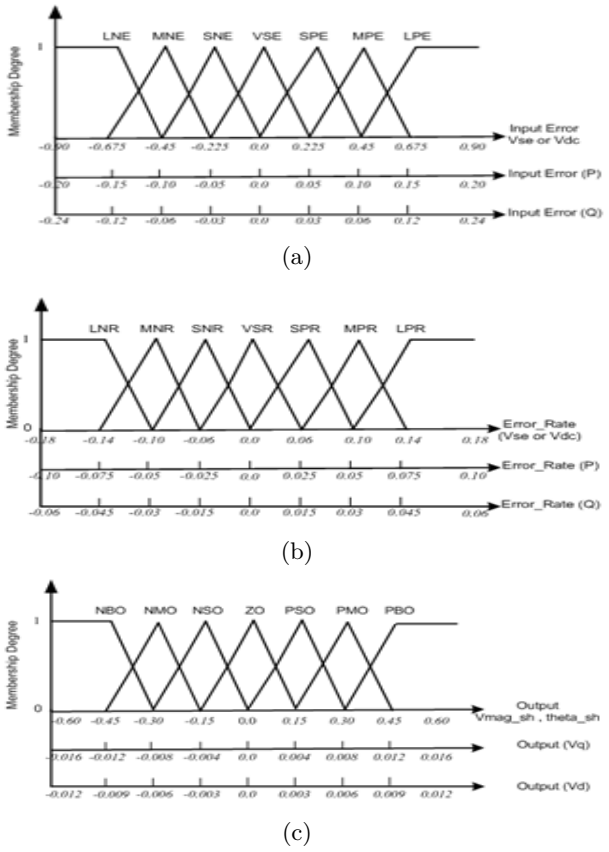

Fig. 13: Membership Functions of normalized Vse, Vdc, P and Q in IEEE-14 bus system

references of direct and quadrature part of the series injected voltage (V_d, V_q) the shunt injected voltage ($Vmag\_sh, theta\_sh$) are shown in Figure 13(c).

3 Simulation Results

The IEEE-14 bus system is simulated without UPFC to compute the reference values required in the design of UPFC controller. The obtained power system values, such as active/reactive power flow and bus voltage, are used to analyze the effectiveness of the proposed UPFC by comparing the power system values before and after the UPFC installation. The simulation results consist of performance analysis of the proposed FLC based UPFC connected at buses 9-14 and compared with the conventional PI UPFC to show its effectiveness.

3.1 Analysis of FLC based UPFC connected at bus 9-14

The reactive power, active power and voltage profile improvement at different buses under steady sate condition are tested by using FLC based UPFC. The base values for line 9-14 are selected as follows: active power

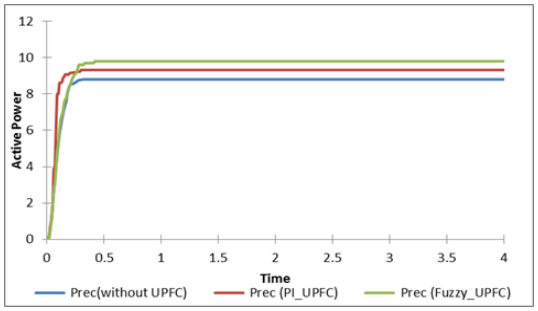

Fig. 14: Active power flow across line 9-14

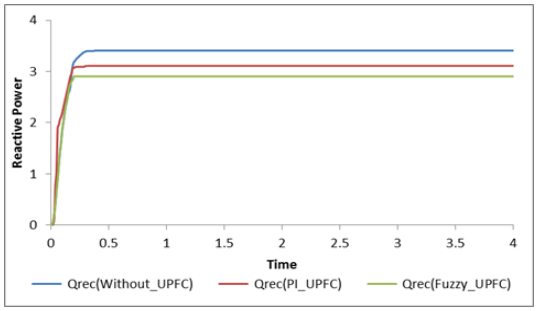

Fig. 15: Flow of reactive power Across Line 9-14

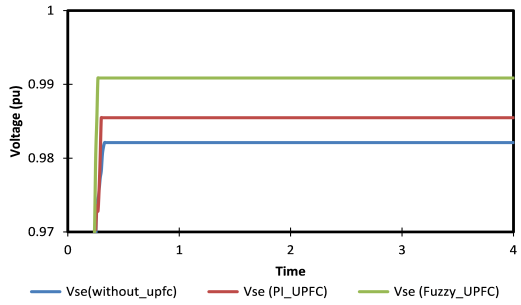

Fig. 16: Voltage at Sending Bus

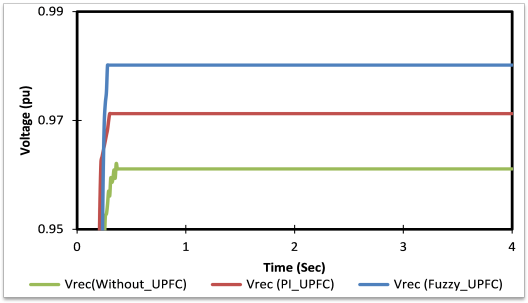

Fig. 17: Voltage at Receiving Bus

= 10MW, reactive power = 2.80 MVAR, and sending end voltage = 1.0 pu. The proposed UPFC, conventional UPFC and the UPFC without response for active power are shown in Figure 14. It can be noticed from Figure 14 that the measured active power flows through the bus 9-14 without UPFC, with PI UPFC, and with fuzzy UPFC are 8.8081 MW, 9.3254MW and 9.8048 MW, respectively. Thus, fuzzy UPFC enhances the active power compared to PI UPFC. Furthermore, it is observed that PI UPFC enhances the power flow by 5.87%. Whereas, the fuzzy UPFC enhances the power flow by 11.31%. Thus, the proposed FLC UPFC has better performance compared to PI based UPFC in terms of controlling the active power at the receiving bus. Similarly, reactive power flow response of all these controllers is shown in Figure 15. It can be noticed from Figure 15 that measured reactive power flow through 9-14 bus without UPFC, with fuzzy UPFC and PI UPFC are 3.4058 MVar, 3.1081 MVar and 2.9032 MVar, respectively. Thus, it is clear that fuzzy UPFC significantly reduces the reactive power compared to PI based UPFC. Furthermore, it is observed that PI UPFC reduces reactive power by 8.74% and fuzzy based UPFC reduces power up to 14.76%. In terms of controlling reactive power at the receiving bus, fuzzy based UPFC shows better performance than PI based UPFC. The voltage profile at sending end bus and receiving end bus are shown in Figure 16-17. It can be visibly understood from Figure 16-17 that fuzzy based UPFC has slightly better voltage profile compared to PI based UPFC for sending end and receiving end bus.

4 Discussion

The response of different power network factors such as active power, reactive power and voltage for IEEE-14 bus test system are investigated with PI based UPFC, FLC UPFC, and without UPFC to evaluate their performance for improving the overall operation of system. Figure 18 shows the percentage-wise improvement in active power by PI controller and fuzzy based UPFC controller. Whereas, Figure 19 shows the percentage-wise improvement in reactive power by PI controller and fuzzy based UPFC controller. It

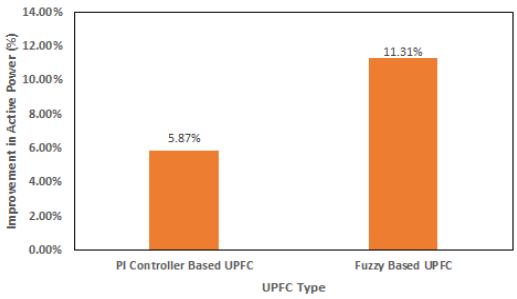

Fig. 18: Percentage-wise improvements in active power by UPFC controllers

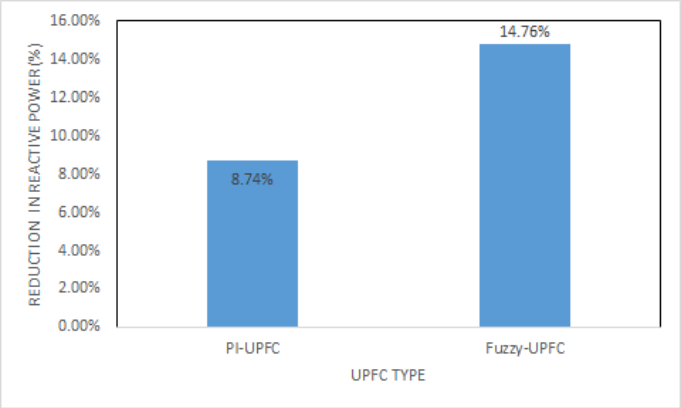

Fig. 19: Percentage-wise reduction in reactive power by UPFC controllers

can be observed from Figure 18 that percentage-wise improvement in active power by PI controller based UPFC is 5.87%. Whereas, using fuzzy based UPFC, it is improved by 11.31% at the receiving bus of the system. Similarly, it can be noticed from Figure 19 that reactive power reduced by PI UPFC is 8.74%. Whereas, the proposed UPFC reduces the reactive power by 14.759%. The voltage at the receiving bus is also improved by both controllers. Furthermore, similar effects can be observed on sending bus (i.e., Bus 9) with the improvement in active power flow, voltage profiles of all buses in the system and reduction in reactive power. Therefore, the proposed FLC UPFC demonstrates its potential by improving the power flow capacity of the system.

5 Conclusion

The electric power system operates at their peak capacity due to exponential increase in the load demand. To address this issue, we propose and design a FLC based UPFC to overcome the existing problems of UPFC controllers under varying operating conditions. The FLC based UPFC shunt and series controllers have been developed as a stand-alone module and applied on IEEE-14 bus. In order to demonstrate the effectiveness of FLC UPFC, its response is matched with PI based UPFC and without UPFC. The simulation results affirmed that FLC based UPFC has improved active power flow at receiving bus up to 11.31% in contrast to 5.87% improvement by PI controller based UPFC. In addition, the power loss without UPFC, with PI based UPFC, and fuzzy based UPFC are found to be 1.20 MW, 0.68 MW and 0.20 MW, respectively. Furthermore, the proposed fuzzy based UPFC has reduced the reactive power by 14.76%, compared to PI based UPFC which has reduced it by 8.74%.

Hence, it can be concluded that using FLC based UPFC, the active power flow can be enhanced, while the power losses can be reduced, resulting in better voltage profile of the existing transmission system. Thus, by using UPFC devices, the capacity of the existing power systems can be enhanced to meet the increased load demands.

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Sizing of a Standalone Solar Home System for Rural Electrification in Thar

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Abstract

The worth of autonomous solar home systems is associated with the precise sizing of system components. This paper presents a simplified intuitive method for sizing of solar home systems which assures the least possible cost at a preset power reliability to satisfy load. The system is sized by considering two most expensive components of solar home system, namely PV module and battery storage. A case study for sizing of solar home systems components was carried out for a load demand of 105Wh/day and 405Wh/day for rural electrification in Chachro, Thar. The system was sized to supply power for two autonomy days. The system slope was optimized for two different scenarios based on worst month and yearly average. The optimized angle was found to be 51° and 23.9° with the power output increase of 42.6% and 10.6% for first and second scenario, respectively. It was established that the systems could be successful in Thar if properly monitored and maintained on regular basis.

Keywords—Rural electrification, Sizing of solar components, Solar home system, Thar.

1 Introduction

Energy is a key to economic development and fundamental aspect to improve the quality of life [1]. Nearly 1.6 billion citizens are living without access to electricity worldwide [2]. It is the prime need to supply electricity at affordable prices to every individual. It is reported that approximately 70.4% of Pakistanis have grid connected electricity, 60% of that are living in countryside and 93.0% in urban areas. The government of Pakistan electrified 85,000 villages out of 125,000 un-electrified villages in 2005. The remaining 40,000 villages, consisting over three million families still use conventional sources to fulfill energy needs. The total number of villages in Sindh is 66,923 as per census of 1998 [3], and electrified only 21,799 numbers up to February 2008 [4]. The remaining un-electrified villages in Sindh are therefore 45,124. It is inferred from the reports that 67.4% villages are still devoid of the electricity. It is also reported by WAPDA that these un-electrified villages cannot be connected to the national grid in near future due to their remoteness from the national grid and other technical and economic problems [4].

Since every community deserves to have the basic facilities of life such as health, education and communications. The isolated villages should also be electrified with any means. However, it is quite difficult task to be solved easily except the installation of solar photovoltaic systems. These systems are practically viable in the places where the installation of transmission lines is expensive. Larger solar systems are costly due to addition and replacement of storage batteries at regular intervals. Thus, smaller systems are preferred due to their affordable prices and fewer maintenance requirements. A solar home system typically consists of a single solar photovoltaic panel or module, a charge controller, a battery for storage, and light electrical appliances as shown in Figure 1. The electrical load appliances may be small lighting appliances including energy savers, bulbs and/or LED lights, minor broadcasting devices, cell phone chargers, DVD players, television etc. All supporting components, which are not included in the major categories of solar home system, are named as balance of system components, which comprise of panel fixing poles, stands, tools, cables, switches, circuit breakers, fuses, measuring instruments etc [5].

Furthermore, the precise sizing of solar home system components is an important part of system design [6].

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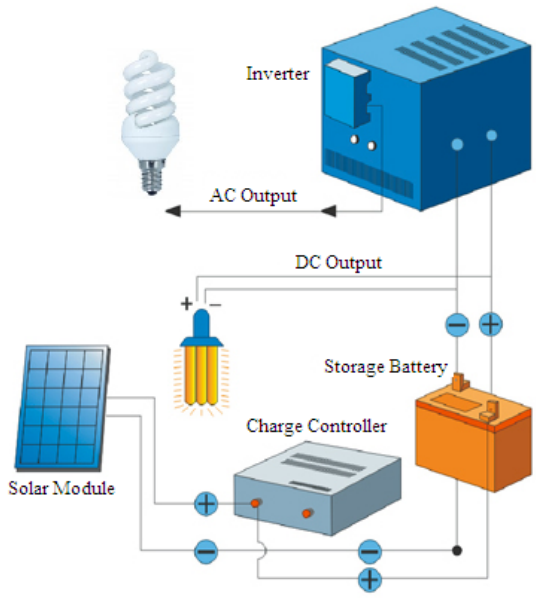

Fig. 1: Components of solar home System .

The development of these systems is associated with correct sizing of components, which in turn depends on the reliable data of the required variables and load profile [7]. The use of long term (more than 20 years) time series data with computer simulations is a best alternative for sizing of solar home systems. However, in many places such data is not available, and computer programs need skills, which is not an easy job [8] [9]. Due to the unavailability of required data, these systems became over-sized or under-sized. Over-sizing turns out to be a costly alternative, whereas the system breakdown happens due to under-sizing which makes the system less consistent. Therefore, proper sizing of solar home system needs careful consideration of two influential factors namely the system cost and power reliability for sustainable supply of energy to satisfy load demand [10].

1.1 Sizing Methods

Sizing methods can be categorized into three main groups namely intuitive, numerical and analytical [8] [9]. Intuitive methods are easy to implement and are proved suitable for obtaining the preliminary approximation of autonomous solar systems [11]. The required PV area is carefully chosen to assure the generation and supply of average energy demand of the designed period (most probably worst month). The projected power output of PV should be more than the energy demand by a safety margin. A similar procedure is required to be followed as that of PV area for the selection of the battery storage capacities. In contrary to the intuitive techniques, numerical methods are based on the simulations of the system behavior. Computer simulations are executed at hourly, daily or monthly intervals with long term (more than 20 years) time series data. Energy steadiness of the system and charging/discharging behavior of batteries are computed for each time interval by assuming constant efficiency of the PV module. Different empirical models could be found for evaluating the performance of standalone solar photovoltaic system components by these methods. However, numerical methods have two limitations, as these are time consuming and require long term solar radiation data. Since analytical methods use algebraic equations describing the sizing of standalone solar PV systems as a function of power reliability [12]. These methods provide practical link between the variables to the sizing problem in an analytic form. Besides the above three methods, a number of combined numerical and analytical techniques have also been studied by various researchers [13] [14]. It is revealed from literature review that the intuitive techniques are simpler among other methods and suitable for approximation of system sizing. Numerical methods are rather complex, need long-term solar radiation data and are also time consuming. Analytical methods provide acceptable results and give explicit relationship between the variables to the sizing problem by means of mathematical equations [14]. The motivation of the work presented in thsi paper is to size the solar home system for rural electrification in Thar. It presents a simplified intuitive method to determine the sizing of solar home system components in usable form [8] [9] [14].

1.2 Sizing of Solar Home System

Sizing of solar home systems is mainly governed by two factors, namely the load demand and the amount of solar resource available to power the system. These both factors determine the quantity and size of solar system components.

1.2.1 Load Demand

Loads are the appliances that take out power directly or indirectly from the system for a particular moment. The first step in the sizing procedure is to select the electrical appliances. Since solar modules generate DC power, whereas, electrical appliances are usually AC powered. Therefore, the function of power inverter is to adapt DC power to AC for utilization in solar home appliances. The inverter itself acts as a load due to conversion efficiency losses resulted from the parasitic power draw. However, in many applications, inverter is not chosen due to its price and convolution [15]. In such cases, DC electrical loads, such as compact fluorescent

light and light emitting diodes, small radios, portable digital video disc players and DC powered televisions are linked directly into a 12 volt DC solar home system circuit. The next step is to determine the wattage of each selected item. Usually, the wattage of electrical devices is stamped or printed on a nameplate on the back of the item. If only amps are listed, they are multiplied by the nominal voltage of that item to find the wattage. If the consumption rate of appliance is known, then Eq. 6 can be used for the calculation of the energy consumption EL that any type of load consumes in day (Wh/d).

$$E_L(Wh/D) = \frac{n \times P_L \times H_d \times D_w}{7} \tag{1}$$

Where η denotes the number of that type of load, (PL) is the power consumption of load, Hd is the number of hours power is consumed in a day and D_w is the number of days the load is used throughout a week. The total load demand per day (Wh/d) of overall load is obtained by adding different load consumption.

$$D_L(Wh/D) = \sum_i E_{Li} \tag{2}$$

where the DL is the total load demand (Wh/d), which is the summation of the individual i load consumption in Wh/d. Similarly, the yearly load consumption is calculated as by multiplying days of year with total Wh/d. The total wattage installed or maximum power wattage PT is calculated by summing the PL of all individual i loads as,

$$P_T = \sum_i P_{Li} \tag{3}$$

1.2.2 Available Solar Resource

The amount of sun light obtainable to the solar module to produce electricity is termed as solar resource. Two terms are commonly used for availability of solar resource namely solar irradiance and solar insolation. Solar irradiance is the magnitude of solar intensity confronting a particular area, measured in watts per meter square (W/m^2). Above the earth's atmosphere the value of solar irradiance is almost constant with 1,367 W/m2. Its value is 1,000 W/m^2 on earth's surface at the equator in a clear sunny day around noon. Solar insolation is the quantity of solar energy reached to a particular area determined in kilowatt hours per meter square (kWh/m^2). Solar insolation of 1 kWh/m^2 is equal to one peak hour (peak sun hour). All solar PV modules are rated at standard condition of 1000 W/m^2 (one peak hour) at 25°C by the manufacturers. Therefore, for calculations, mostly peak sun hour is refereed. For example, a 100 Wp module will produce 100 Wp, if the solar irradiance striking on the module is 1000 W/m^2 with a module temperature of 25°C. Higher temperatures, hazy and cloudy conditions will lessen the power output of photovoltaic. If a location has a peak sun hour of 5, and if the standard rating of solar module is 100 Wp, then it will produce 100 W x 5 = 500 Wh of electricity per day, presuming that the temperature of the module is remain constant at 25°C.

1.2.3 Sizing of Solar Module

The electricity produced per day by a solar module or panel EP can be calculated as follows,

$$E_P = S_P \times P_r \tag{4}$$

where E_P is daily electricity output of a single solar module or panel (Wh), S_p is the number of peak sun hours (hours) per day and P_r is the rated power output of solar module or panel (W_p). Generally, at least 20 percent safety factor is added to the actual load demand, as the batteries and inverters consume or temperature affect a certain amount of the power generated by the solar modules or panels. The number of modules or panels N_p is thus calculated as follows:

$$N_P = D_L \times 1.2/E_P \tag{5}$$

1.2.4 Sizing of Storage Battery

It is necessary for the owner to decide the days of autonomy for the system to supply power during the periods of little or no sun, or without any electricity generated by the solar modules or panels. Batteries are commonly rated by taking discharging period of a fully charged battery to 10.5 Volts in twenty hours at 25°C, which is indicated as C/20. The discharge ratings of the ordinary batteries are taken as 100, 10 or 6 hours. Let's say, a 200 Amp-hr C/20 rated battery signifies that the battery can deliver 10 amps for 20 hours (C/20 = 200/20 = 10). Since, 200Ah battery has a dissimilar capacity rating at other discharging rates. The disparity in their capacity caused by discharge rate is termed as Peukert effect. The higher rate of battery discharge results the lower battery capacity as shown in Figure 2. The numbers mentioned on every line of graph indicates the Peukert number, which is specific to every type of battery. A 120Ah rated battery with Peukert number of 1.2 (indicated with red route), becomes a 60Ah battery at current extraction is 30 Amps. It is to be noted that the rated battery capacity is different from the operating battery capacity. The Peukert effect can play a major role when the ultimate load current exceeds the battery rated (C/20) discharge rate. In such cases, the designed storage capacity of the battery becomes smaller and smaller

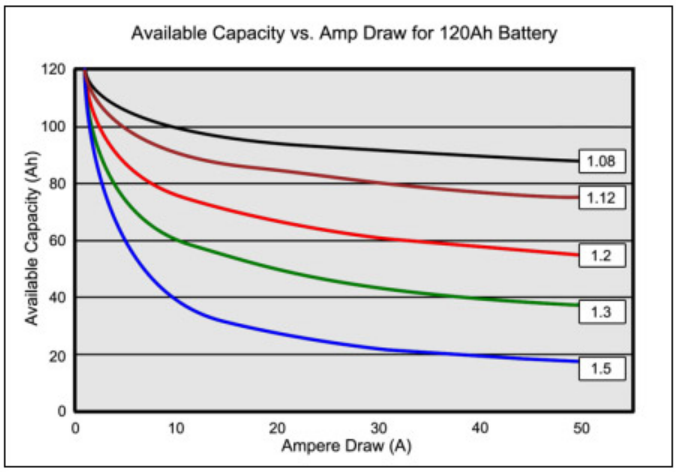

Fig. 2: Peukert effect on available capacity. Adapted from Battery University

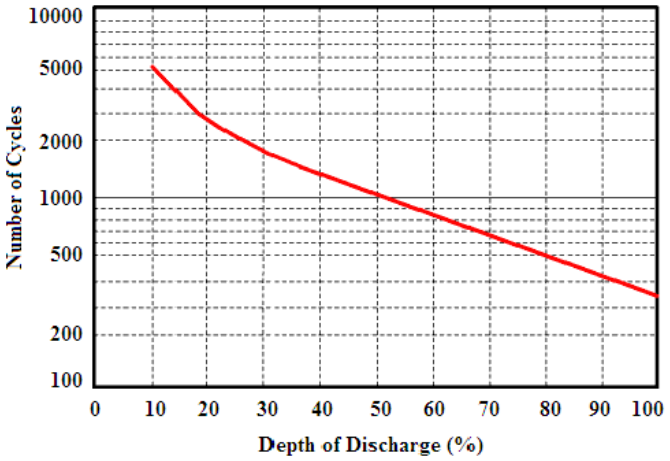

Fig. 3: Battery life cycle versus depth of discharge.

resulting in more discharge which further lowers the battery voltage, taking out the additional current. For example, if voltage declines, current will rise to retain the unchanged power level, because power = volt x amp. Consequently, it results in more shrinkage of the battery capacity [16].

There is another factor that makes battery sizing more problematic. The practical battery capacity is more decreased by life of battery versus depth of discharge as shown in Figure 3. Here, the y-axis is in logarithmic scale. Due to these effects, usually there is a conciliation among battery capacity, its life and replacement costs. The most common accepted trade-off for usable battery capacity is 50% depth of discharge [17]. Once the battery capacity is determined, the number of batteries required can be calculated as follows,

$$N_b = D_{L,b} \times D_A / (C_b \times DOD_{max}) \quad (6)$$

where N_b is the number of batteries required, DL.b is overall necessary battery capacity (Ah/d), DA is the number of autonomy days that battery will supply energy when there is no output from solar modules due to cloudy skies, Cb is the nominal capacity of a single battery (Ah) and DODmax is the maximum depth of discharge of the battery per day. Since, the voltage of batteries will be adjusted or maintained as per required system voltage.

2 Methodology

Sizing and installation of an autonomous solar home system was carried out for Chachro (25.12°N, 70.25°E), District Thar, Sindh. Monthly average daily solar radiation data of 24 years was used for this study, which was acquired from NASA [18]. The system sizing was carried out for a load demand of 105 Wh/d and 405 Wh/day with two autonomy days. It was presumed that the electrical demand is same during the whole day. The system slope was optimized for two scenarios namely worst month and yearly average methods. The three most important and sensitive parameters were considered for this study includes solar radiation, ambient temperature and system slope. The maximum battery depth of discharge DODmax was taken as 50%.

3 Case Study for Sizing of a Solar Home System

The case study performed for the sizing of a solar home system comprises the following steps.

3.1 Estimation of Solar Insolation

The estimation of solar insolation of the selected site was made using 24 years data acquired from NASA [18] as shown in Figure 4. It was found that there is a little variation in the amount of solar radiation between the summer and winter from 2 to 3 kWh/m2/d. The average amount of solar radiation in December is about 3.7 kWh/m2/d and January 4.1 kWh/m2/d. The highest radiation level is confronted in the months of May with 6.40 kWh/m2/d and June 6.36 kWh/m2/d. However, the average annual solar radiation is about 5.2 kWh/m2/d. In the worst months, i.e. in December and January, the average monthly solar insolation is around 3.9 kWh/m2/d. If the system is optimized based on worst month (December) then the radiation capturing could be enhanced from 3.75 kWh/m2/d to 5.35 kWh/m2/d with an increase of 42.6% for that particular month. When the system is optimized on yearly basis, then the system output could increase

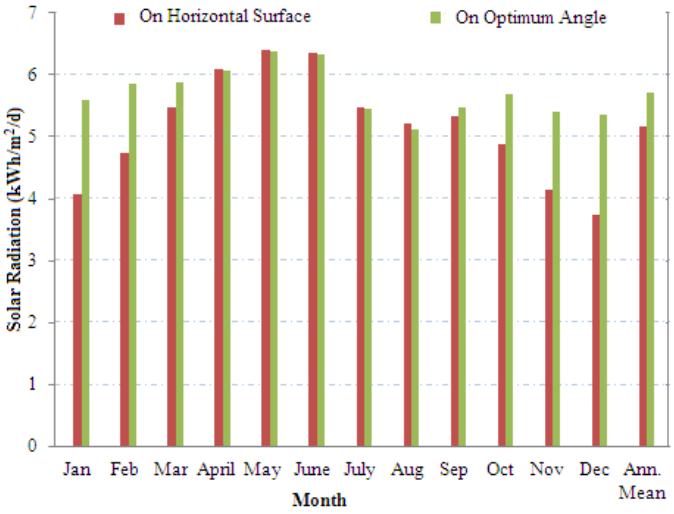

Fig. 4: Solar radiation intensity of different months at Chachro, Thar.

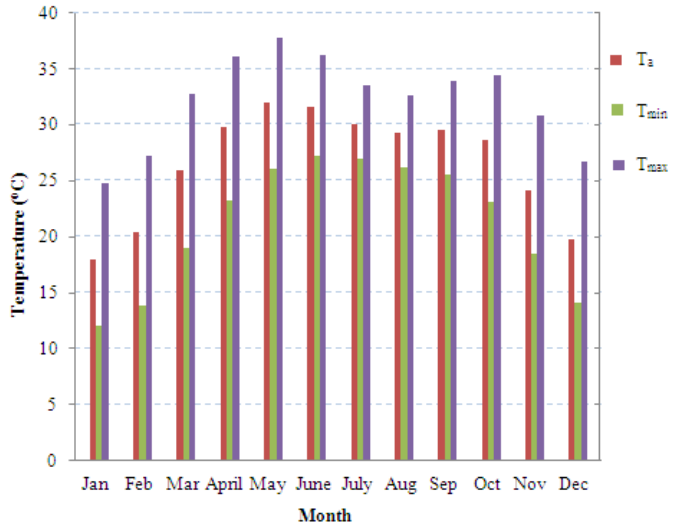

Fig. 5: Temperature profile during various months of year at Chachro, Thar.

from 5.16 kWh/m2/d to 5.71 kWh/m2/d with an increase of 10.6%.

Furthermore, the higher temperatures decrease the performance of solar photovoltaic panels. Therefore, the study of air temperature of the area was carried out for incorporation of system design process. Figure 5 characterize the monthly average ambient, minimum and maximum air temperature at Chachro, Thar. It was found that the average annual mean of ambient air temperature at the site was 26°C. The lowest average monthly minimum air temperature was recorded in the month of January with 12.1°C and the highest average 27.2°C in June. The highest average monthly maximum air temperature was recorded in the month

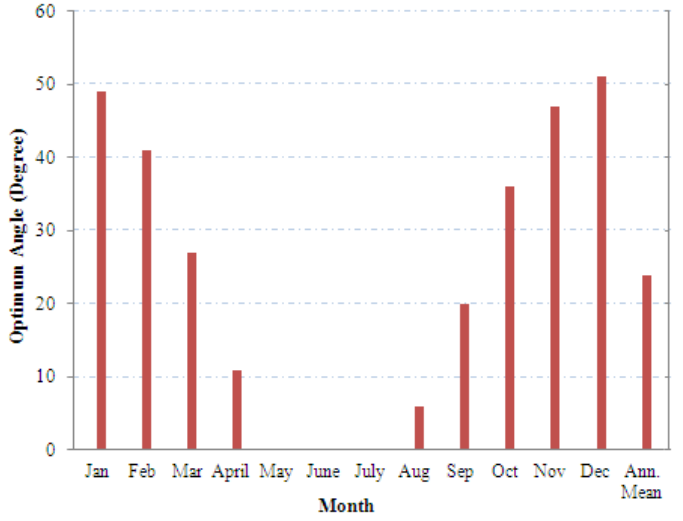

Fig. 6: Monthly average optimized angle for installation of PV panels at Chachro, Thar.

of May with 38.0°C and the lowest maximum average 24.7°C in January. It is revealed from the analysis that the air temperatures in the months of July and August were relatively low as compared to the months of May, June, September and October due to cloudy skies and monsoon season.

3.2 Orientation of Panels

In addition to the estimation of solar data and considering the influence of temperature, appropriate physical orientation of the panels is indispensable for trapping more solar radiation that striking the panel surface. In general, for a fixed mounted panel, the panel is tilted towards true south at the latitude of location. If the system is designed for winter, then the tilt angle is set with latitude +15° [19]. It is found that, on annual average basis, the optimized angle at Chachro was 23.9°as shown in Figure 6. The maximum optimum angle was found to be 51°in December and 49°in January. The less optimum angle was zero for three months from May to July. If a solar system has a steady load demand, then the designed month will be of less solar insolation month. However, a minimum of 15°tilt is preferred irrespective of the location latitude to facilitate the self-cleaning of panels during rains.

3.3 Proposed Applications of Solar Home Systems

The two different models are proposed for solar home system applications as described in Table 1 and 2. The first model is tabulated for a daily load demand of 105 Wh and the second one is for 405 Wh. The

first model is chosen for lowest income people or small users, whereas, the second one is proposed for relatively larger communities and middle class people. The number and selection of system components are made after receiving the specifications from the suppliers. Since the cost of equipment is not provided by the suppliers, therefore, it is not included in this study.

It is established from the study that autonomous solar home systems are quite feasible for the supply of electricity to the rural communities of Thar region. However, the government or other agencies should monitor and maintain the systems in regular intervals of time. It is also recommended that the selected groups from the end-users must be trained in order to examine and uphold the solar home system components. Unprofessional home installations can create problems by installing the PV panels on the traditional thatch roofs. The roofs are made in the shape of cone in the Thar area which requires special installation method. If the PV panels do not face true south, the improperly trapped energy will result in a wastage. A careless installation of systems should be avoided that leads to an under-performing and short-lived system due to battery under charging.

4 Conclusion

It is difficult to supply electricity at affordable prices to the isolated communities settled in Thar where the extension of transmission lines from national grid is expensive and other resources are lacking. The installation of solar home systems is only practicable solution to this fundamental problem. However, the proper system design and maintenance is crucial to meet the demand under different environmental conditions and cost constraints. Therefore, a simplified intuitive method is used for sizing of solar home systems with a load demand of 105 Wh/d and 405 Wh/day for two autonomy days. The two key parameters were considered for the design of solar home systems, i.e. the solar resource and energy demand that will increase the lifespan of system components. The system slope was also optimized for two scenarios, namely worst month and yearly average methods. The optimized angle was found to be 51°and 23.9°, with the power output increase of 42.6% and 10.6% for first and second scenario respectively. It was established that the systems could be successful in Thar if properly monitored and maintained on regular intervals of time.

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TABLE 1: Proposed Model-1

Appliance	Model Specification	Load Power (W)	Quantity	Work Hours Per Day	Total Wh/-day	Autonomy Days
Light	PAE-7W-2U12VDC	7W	2	7.5	105	2

TABLE 2: Solar Home System Equipment (Proposed Model-1)

Description	Model	Power	Quantity	Total Capacity
Solar Module	THD25/12-AE4/9	25Wp	1	25Wp
Storage Battery	BT38-12	40Ah/12V	1	40Ah
Charge Controller	EPHC 5A/12/24V	5A/12V/24V	1	5A

TABLE 3: Proposed Model-2

Appliance	Model Specification	Load Power (W)	Quantity	Work Hours Per Day	Total Wh/-day	Autonomy Days
TV	PAE-11W-2U12VDC	11W	3	5h	165	2
Table Fan	PAE-12VCD 30W 14”	30W	1	8h	240	
Total					405	

TABLE 4: Solar Home System Equipment (Proposed Model-2)

Description	Model	Power	Quantity	Total Capacity
Solar Module	THD100/12-AE6/18	100 Wp	1	100Wp
Storage Battery	BT150-12	160Ah/12V	1	160Ah
Charge Controller	EPHC 10A/12/24V	10A/12V/24V	1	10A
Inverter	PI-3-12(230VAC)	300W	1	300W

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Analysis of Factors Affecting the Learning Enhancement of Primary School Children Using Smart Devices

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Abstract

The traditional learning styles are driven towards digital learning paradigms, such as e-learning and mobile learning (M-learning). The innovative trends in the technology have focused on finding new approaches for improved learning techniques and M-learning is one of them. The M-learning is a new and dynamic field of research which is constantly evolving in developed and developing countries. The use of mobile devices has recently increased in educational institutions for online learning and information gathering at any time. With the new era of information technology, learning trend is rapidly changing throughout the world with the aid of different learning platforms to the children. However, it is very important for Pakistan to promote M-learning and generate the new pattern of learning that will facilitate children to enhance their learning skills by using smart devices such as Tablet PCs and smartphones. In this paper, the role of M-learning and the factors which affect it are analyzed. An education based interactive application for primary school students on smart devices for M-learning has been developed in order to analyze the learning skills of the students. Our results show that M-learning, especially learning through interactive applications on smart devices, plays a vital role in enhancing the learning skills, learning interests and knowledge spectrum of the students.

Keywords—M-learning, E-learning, interactive learning, learning through games, mobile learning.

1 Introduction

Mobile Learning (M-learning) is one of the rapidly growing fields in educational institutes all over the world. M-learning is a revolution in e-learning that uses the electronic educational technology in learning (i.e., M-learning). It provides the learners with improved access to data, learner-centered approach, enrichment, high quality and new ways of interaction to enhance their level of knowledge and interest towards the education using smart devices (such as Tablet PCs, PDAs, iPads, mobile phones). The M-learning plays significant role in the formation of universal knowledge based society. In modern era, M-learning approach is one of the powerful tools for standard education in most educational institutes all over the world.

The important consideration from the educational point of view is that by incorporating modern technology oriented tools in education, such as learning through the mobile games or other interactive applications, can produce the positive feedback from the children. The authors in [1] suggest that the game-based learning can achieve better learning results than the traditional classroom learning. The tremendous success of M-learning in developed countries shows that M-learning contributes significantly in improving the educational outcomes. Hence, Pakistan should also take immediate measures to introduce this mode of learning at each educational level to make future of Pakistani education bright in universal knowledge based society.

The UNESCO project [2], launched in collaboration with Nokia in Pakistan, shows that the quality of the teaching in remote areas of Pakistan can be improved using mobile technology. UNESCO and Nokia together have introduced a Mobilink learning project for teachers' professional development for public schools in remote areas of Pakistan in order to deliver learning resources using Nokia's education delivery application. Smart device technology has enabled people from almost every walk of life to carry their own mobile

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assistant with them all the time. These mobile devices include Personal Digital Assistants (PDAs), tablet PCs, e-readers and smart phones. These devices have tremendous potential for both traditional classroom learning and out-of-classroom informal learning [19].
The rest of the paper is organized as follows. Section 2 outlines related work in this domain. Section 3 describes the factors affecting the learning behavior. Section 4 discusses the proposed framework. Section 5 describes the results and discussions and section 6 concludes the paper.

2 Related Work

Mobile learning (M-learning) is derived from e-learning which is a portable technology composed with wireless and mobile phone networks which facilitates the learners to enhance their level of understanding towards the particular topic anywhere and anytime. The educational results of students are affected by the usage of interactive learning applications using smart mobile devices [5]. The adoption of the e-learning implementation at a private university in Indonesia has isolated the behavior of the students towards the ICT [4].
M-learning also has positive influence for the behavior, attitude and interest in students of colleges at American higher education institutes [8]. An M-learning process for pre-school children also affects the educational period of children and teachers [3]. Mobile learning also has a positive effect on educational achievement and self-regulation [6]. In M-learning, cultural factors have also significant impacts for culturally diverse country such as Pakistan [7], as mobile culture is an integral part of our daily life and young people bring mobile phones with them all the time and continue to use them for playing games and internet surfing [9].
According to students' perception, the role of the teacher is very important in M-learning at developed countries [10]. Most of the teachers favor the use of technology-oriented tools during their lectures in the classrooms for facilitating the students to understand the lecture topics more easily [11]. The distance learning via SMS facility of Open University Malaysia is an initiative which enables the university students from remote areas to learn through mobile devices [12]. One of the significant uses of mobile phones for playing games indicates that the learning interest of students is enhanced through mobile games [14]. M-learning impacts the learning outcomes by improving the access to the education with alternative learning process [13]. The mobile game development is rapidly growing due to the increased use of mobile devices which may also have positive influence in the educational institutes [14]. The game based learning features also contributes to the engagement of participants in a topic and they feel fun by learning through the mobile games [15].

3 Factors Affecting Learning Outcomes

There are a number of factors that affect the leaning outcome and behavior of children using smart devices. The M-learning technique facilitates the children from different aspects which are discussed in the following sections.

3.1 Activity Based Learning

This type of learning enhances the learning interest of children using smart devices and has shown significant impact on the children outcome in education. The activity-based learning provides a variety of educational material in different aspects and children may be engaged through different activities according to their level of interest.

3.2 Ownership

Ownership is also perceived as a powerful motivational force for individual learners. Ownership includes using own device, privacy, availability and mobility which allow the learners to access information all the time and staying connected with friends, family and the rest of the world.

3.3 Collaboration

Collaboration is one of the greatest experiences for mobile learners which provides them a chance to work together from remote locations. Learners can interact with their trainers and colleagues anytime and from anywhere. M-learning allows the learners to share their ideas within a group and get a quick feedback. Mobile learning facilitates the learners with various online apps such as Google Apps that allow the learners to work collaboratively. The M-learning context is more than on-demand and the mobile learning extends learning from the classroom to the real-world practice. There are a number of opportunities for the learners in M-learning such as they can choose a course on their own demand. M-learning also enhances the learning experience of the learners for both formal and informal learning practices. Leaning is everywhere and anytime such as waiting for the train at station and the context of M-learning is more than the time and space [17]. By this way, learners can learn more effectively and efficiently in flexible and comfortable environments [18].

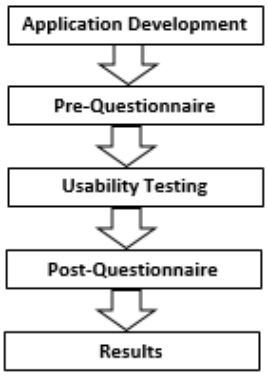

Fig. 1: The proposed framework

3.4 Learning as a Fun

Learning as a fun also has a positive effect on educational outcomes of the children, because when children have fun, they are more creative and innovative and are able to engage with whatever they are learning through coming up with new ideas. Learning as a fun looks for providing free learning activities to children according to their interest such as children learn through mobile games according to their choice (math, English, etc). These additional benefits of mobile application facilitate the learners to learn with fun [20].

3.5 Feeling Happy

Feeling happy is also one of the motivational factors for the children leaning through mobile games. M-learning provides the learners with entertainment at their fingertips. Starting to learn with the help of games on their own smart devices has a positive experience for improving the learning skills of the students [16].

4 Proposed Framework

Our proposed framework is depicted in Figure 1. The following sections explain the various steps of our proposed framework.

4.1 Application Development

In the first step, we develop an Android-based alphabet learning application, namely "English Alphabets Learning Application" for children. The idea behind the development of the android application is to use it for analyzing and measuring the interest of the children for learning through mobile devices with the help of usability tests.

4.2 Pre-Questionnaire

A number of the questions are asked from the children before testing the developed application which are helpful for understanding the level of the interest of the children towards M-learning.

4.3 Usability Testing

The developed application is tested in real environment on the children of class nursery, kindergarten and one. During this phase, 5 primary schools are visited for conducting application tests. These schools include both private and public sector. A total of 155 students participated for usability testing. The application contains multiple activities for children's understanding. The students were able to learn through different aspects as per their interest. This helped to analyze the user experience of the children.

4.4 Post-Questionnaire

At the end of the usability testing phase, a post-questionnaire are distributed among the students which contains a number of questions for the children about the user interface and the use of the application.

5 Results and Discussions

We adopt a collaborative classroom setting by making the students sit together around the tables in the classrooms. Before the usability testing of the application, some pre-questionnaires are distributed among the students for collecting the basic information about the use of smart devices. Subsequently, we give a demo to the students about the use of the application. Some of the basic questions asked from the students and their respective answers given by the students are shown in the Table 1. At the end, the post-questionnaire are distributed among the students for knowing the understanding and interest of the students using the smart devices.Table 2 shows the usability test questionnaires asked from the students after the pre-questionnaire.

After the usability testing, post-questionnaire are distributed among the students. Table 2 shows the post-questionnaire questions asked from the students. Furthermore, the feedback of the students about each questionnaire is shown in the following Figure 2-6. Figure 2 shows the feedback of the students on the usability experience of the developed application. 89 students strongly agree, 31 agree, 21 are uncertain, 9 disagree and 5 strongly disagree, respectively.

Figure 3 shows the feedback of the students on the understanding of the alphabets using the developed application. 81 students strongly agree, 47 agree, 15

TABLE 1: Questions asked before the usability testing

Age in Year	3 to 4 5 to 6 6 to 7	60 65 30
Gender ratio	Boys 53.55%	Girls 46.45%
Class-wise students	Play Group KG Nursery One Class	44 24 55 32
Familiarity About Smart devices	YES 76%	NO 24%
Learning through Interactive Tools	YES 73%	NO 27%
Availability of Smart devices	YES 82%	NO 18%

TABLE 2: The questionnaire of the usability test

S.No	Question
1	Is this application interesting and easy to use?
2	Did you understand easily through this application?
3	Will you use this application at your home?

are uncertain, 9 disagree and 3 strongly disagree, respectively.

Figure 4 shows the feedback of the students regarding the use of the developed application at their homes in order to learn English alphabets using this application. The results show that 83% of the students are willing to use this application at their homes for learning English alphabets and 17% are not interested to use this application.

The application developed is based on five basic activities for learning English alphabets. Each activity is defined by different ways of learning for the students to learn through different techniques and interests. Figure 5 shows the feedback from the students regarding activity wise interest of the students. 73 students are interested in ABC-Chart activity, 61 in Finger-Swipe activity, 9 in Click-to-Next activity, 8 in Auto-play and 4 are interested in Alphabets activity.

The traditional learning and M-learning methodologies are compared and the feedback from the students regarding the traditional learning system and M-learning system is obtained. The results of the feedback as given in Figure 6 show that 51% students are interested in the interactive learning, 41 in traditional learning and 8% are interested in both traditional and interactive learning.

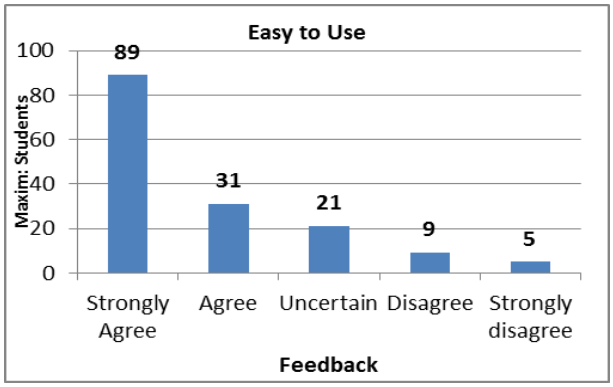

Fig. 2: Usability of the developed application (easiness to use)

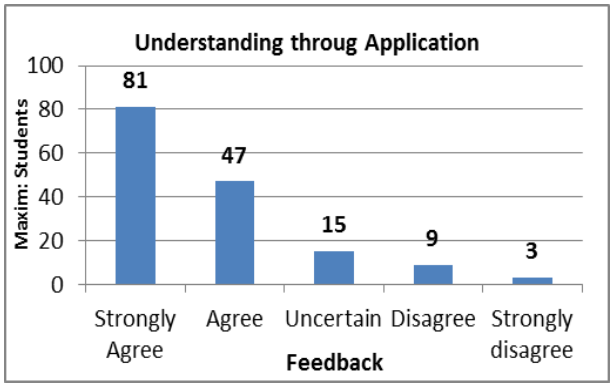

Fig. 3: Usability of the developed application (understanding through the application)

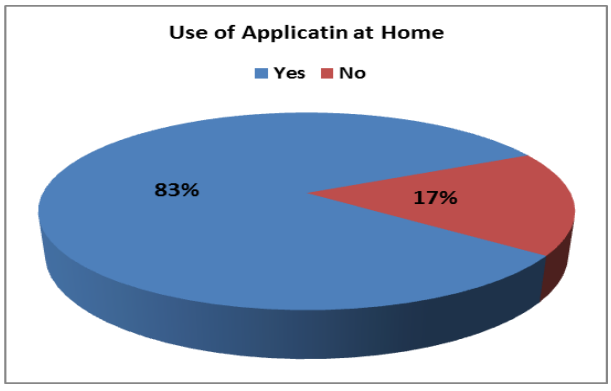

Fig. 4: Usability of the developed application (use of the application at home)

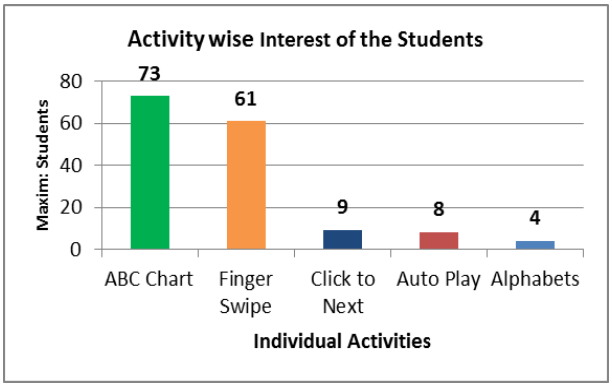

Fig. 5: Activity-wise interest of the students

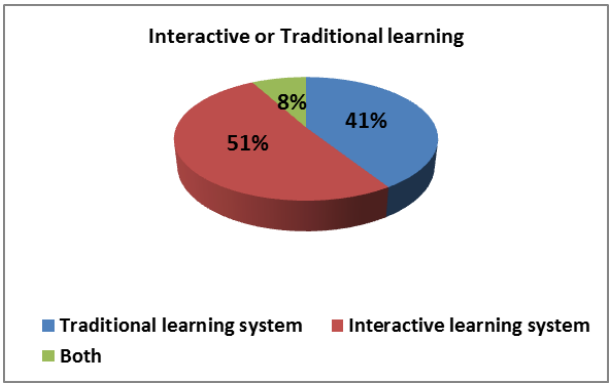

Fig. 6: Interactive vs. traditional learning

6 Conclusion

The mobile learning enables the education delivery everywhere/anytime. Mobile learning facilitates the students with verity of integrated learning activities, especially the use of the smart devices as interactive learning tool. Mobile learning has potential to produce innovative pattern of learning that may facilitate the students to enhance their learning skills. This research study concludes that interactive learning (M-learning) has significant impact on the leaning outcomes of the students. In addition, five factors are analyzed as activity based learning, ownership, collaboration, feeling happy, and leaning as a fun that can enhance the learning interest of the students. Moreover, an educational learning application was developed for analyzing the learning interest of the students. The results of this research study show that 72% of the students are interested in interactive learning methodology, such as M-learning, through mobile games and other interactive learning tools. During the visit of the schools for usability testing of the application, it was found that most of the private sector schools are already using interactive learning tools such as FlexiMaster, but they are not using these tools on regular basis. However, in the government sector schools, there is no existence of interactive learning practices. Therefore, it is important for education department of government of Pakistan to take vigorous steps for promoting the interactive learning (M-learning) in order to be a part of the global society.

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Assimilation of Monitoring System for Emergency Power System

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Abstract

A Monitoring and logging system for Emergency Power System (EPS) reduces the risk of power backup interruptions during outages. The reason behind proposing this system is negligence of preventive maintenance of EPS, which may cause disruption due to malfunctioning. Monitoring and logging system are helping in reducing such situations. It monitors the log of EPS on the basis of selected parameters such as voltage, current, temperature and load, and generates alerts in case if any of the selected parameter exceeds from its safe range. After sending alert through SMS via GSM, a preventive measure may be taken to avoid any interruption. EPS systems have enabled the improvement of power source quality, providing clean and uninterrupted power to critical loads such as industrial process controls, computers, medical equipment, data communication systems and protection against power supply disturbances or interruptions. EPS is essential and widely used by industries all over the world to ensure an smooth operation without having the effect of power disruption. A system that is able to monitor this EPS can detect any abnormal activities occurred in the system. In addition, the system can prevent any fault that may affect the whole operations. In this paper, we perform a rigorous analysis of the existing monitoring systems. Subsequently, a monitoring system is proposed and tested. In addition to this, a software application is also developed for logging data for future analysis for management. This system also helps in identifying the root cause along with the frequency of the problem.

Keywords—EPS, interruptions, SMS, GSM, Monitoring System, software.

1 Introduction

One of the major inventions of the last century, the electric power, has become essential for the functioning of any electronic device. With the technological advances came the "rolling systems" which cannot be interrupted such as the ones in hospital equipment, banks, security agencies, media industry and airports, for the non-operation of this equipment can cause serious consequences. A research on limitations in critical operating systems shows that approximately 60% of interruptions in operations are caused by the problems related to the supply or electricity infrastructure such as power outages, blackouts, faults in transformers and failures of automatic transfer switches [10]. Power quality or interruptions in supply services have become common and have affected the entire industrial process resulting in large economic losses. With the growing electricity consumption by companies and even the masses, energy sector companies have not supplied the demand in certain regions and tirelessly develop new technologies that can mitigate the possible consequences that might occur in the future with the supply of electricity in particular. Considering all these limitations, companies and institutions have sought resources to improve the quality of energy and has adopted reliable emergency power systems and are now able to intervene in possible failure of the commercial power supply in order not to stop all its processes [10].

The use of combustion generator and uninterrupted power supplies have been the most viable alternatives that have shown better results, as the use of these systems can ensure the continued free power surges, ensuring full operation of all processes. Power Systems Engineering Research and Development (PSERD) exercises quicken disclosure and advancement in electric transmission and circulation innovations and makes

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"people to come" gadgets, programming, instruments, and procedures to modernize the electric framework. Undertakings are arranged and executed working together with accomplices from other government programs such as electric utilities, gear makers, provincial, state, and nearby offices, national research centers, and colleges. Coordination is basic to centering government endeavors and guaranteeing that undertakings are legitimately adjusted to open, private, nearby, and national needs.

In this paper, we propose a network model that is reconfigurable for planning the system model to bolster the transmission line observing applications. There are a few elements, for example, delay resistance, vitality productivity, and unwavering quality. Since the message produced among the systems needs to experience a long chain of transfer hubs, the postponement is relied upon to be huge. In the meantime, on the off chance that all the hand-off hubs are required to produce a specific number of messages, the hand-off hubs close to the substations are relied upon to go through significantly more vitality than those among the system over the long term. Likewise, hand-off hubs disappointment in the system may bring about an unforeseen vast region loss of status data. All the issues previously stated can be helped in the event that we can choose a fitting approach to convey data in view of the movement necessities and asset limitations. To offer a relay an alternative way to deliver its data, a relay node is equipped with several kinds of communication devices for different ranges of communication. For instance, Bluetooth, ZigBee Pro, and GSM/GPRS/UMTS. The GSM/GPRS/UMTS device is turned on only when necessary.

2 Critical Analysis of Existing Monitoring Systems

A Sensor Capability Representation Model (SCRM) is studied in the literature which can function as a valuable information source for sensor discovery, cooperative observation capability evaluation, and capability semantic registry. Taking into account the Meta Object Facility (MOF) design, a five-tuple SCRM system, including the center perception, computation, transmission, vitality continuance, and ecological versatility capacities has also been studied. Four particular representation component accumulations for run of the mill remote detecting sensor sorts (e.g., outline camera, scanner, SAR, and non-imaging) are produced to fulfill the solid capacity expression needs. The OGC Sensor ML is used as the expression type of the proposed SCRM. A model framework (SCRMS-SM) is produced for the utilization of the SCRM. A case examination is directed to the dirt dampness application. The versatility of the proposed information model is verified using several different sensor types, namely, optical camera, VIS/IR scanner, SAR of soil moisture monitoring sensors for the SCRM modeling, and capability-based sensor discovery processes. The SCRM can also be extensively utilized in other environmental monitoring and modeling situations.

A fault-tolerant network architecture based on integrated wired and wireless networks has also been investigated [2]. The wired part of the system is the essential system for all hubs in the framework, while the remote system partition is utilized as reinforcement between sensor hubs when there is any failure in the wired associations between them. This new system engineering improves the unwavering quality and execution of the existing systems for pipeline choking.

Another work [10] aims to increase knowledge of these networks in terms of performance, enabling the user to make decisions supported by the instrument. In this sense, the conceptual approach is carried out in terms of Wireless Sensor Networks (WSN), standardization trend for these networks and exploitation by means of software. For demonstrating the benefits of adopting the use of the concept of software instrumentation in these networks, WSNs have been developed using these concepts in which it is possible to evaluate the profile of temporal aspects and connection quality of maintenance. This approach improves the quality of the user's decision-making regarding their use in applications with time constraints in which the response times involved should respect maximum allowable limits.

WSNs are a special type of ad-hoc network that position in a region to monitor physical phenomena. Whereas such networks are independent and have a small radius of coverage, it is common to use a large number of sensors to monitor a large area. A problem in these types of networks is to ensure that the data captured by the sensors is transmitted to a base station for analysis by the users. One approach to solve this problem is through the use of special sensors called cluster heads. These sensors are strategically positioned to collect information from a group of sensors and transmit it to the base station. The authors in [4] propose a hybrid technique based on K-Means clustering algorithm data and detect communities in complex networks. This algorithm, called QK-Medium, tries to take advantage of the two approaches in two stages. First, the network is broken into communities using a detection technique. Then these communities are broken into sub-communities such that the cluster heads

are able to manage. This technique demonstrates that it is possible to reduce the number of messages lost in the network using fewer cluster heads.

The authors in [16] investigate the security implementation challenges in WSN. They further present a design and implementation of security architecture for WSN which aims to provide security in end-to-end communication, enables inter-operability between different systems, and allows greater flexibility in the use of cryptographic keys in different scenarios and typologies. In addition, the proposed solution supports enabling and disabling its services at run-time. The results are presented, specifying the architecture, qualitative evaluation thereof, and the performance evaluation of the implementation developed as proof of concept. In addition, they also present an analysis of the impact of different typologies and disposal characteristics in the task of distributing cryptographic keys in WSNs.

The authors in [8] propose the use of WSNs as environmental monitoring system and support for agricultural spraying process, especially the spraying performed by aircraft. Three features are proposed for the system: (i)evaluation of environmental conditions, making sure that the conditions are appropriate for spraying in order to minimize the occurrence of drift, (ii) maintenance of the spray vehicle route through the wind data in order to make adjustments in the spray path, and (iii) assessing the effectiveness of spraying by means of the deposition of the sprayed product collected data by the sensor network. To enable the use of WSNs in controlling drift, the authors propose a data routing protocol which ensures the collection of data and delivery to the spray vehicle. To demonstrate the feasibility of the proposed system, the authors developed a computer simulation system that considers aspects of WSNs and features of the proposed routing protocol. The results show viability, demonstrating that the WSNs may be used as a support on a drift control system, increasing the spray quality, reducing costs and environmental contamination.

The application developers for WSNs need to use fault tolerance mechanisms. Some of the fault tolerance mechanisms are implemented in hardware, but are most commonly left to software implementation. Furthermore, most of the development applications of WSNs have low-level of abstraction in the operating system. Thus, in addition to having to concentrate on low-level application logic, developers have yet to implement fault tolerance mechanisms with the application by the lack of libraries or generic components for this purpose. Programming techniques at a high-level for WSNs have been proposed in the form of languages and frameworks of macro programming. However, just a few deal with fault tolerance features. The authors in [15] show that it is possible to provide a framework of macro programming with appropriate support for developing applications for WSNs that require fault tolerance.

The authors in [17] introduce a variation of the concept of information efficiency, called efficiency aggregated information, which takes into account the ability of the network to reuse the communication channel spatially. They also present an analysis of aggregated information efficiency of a WSN in different scenarios, using different configurations. The results show that the medium in which the network is used is a decisive factor for performance and plays a key role in the choice of the modulation scheme. It is also observed that transmitting at short distances is more advantageous than transmitting over long distances in most cases.

The authors in [12] collect signal quality of data transmitted between a base station and a sensor node located inside a greenhouse with the aid of computational tools. Inside the greenhouse, a hydroponic system is inserted with benches that provides support for strawberry cultivar Albion. After implantation of the sensor nodes, experiments are performed in order to verify range and signal quality according to their power. Through these studies, it is concluded that a signal power with a value of -12.2 dB suffices to maintain the transmission between base station and Node Sensor. Tests are also carried out for a signal power of -9.2 dBm to show that the network has a quality classified as “very high”. However, through the battery life test, it is noted that there is a higher energy saving when using the signal strength of -12.2 dB. Overall, it is demonstrated that the amount of signal power has influence on the quality of signal transmission and reception, battery depletion and the signal range. Therefore, this is an important parameter to be considered in a WSN deployment project in the farming environment.

The authors in [9] describe the procedures for installation, configuration and use of a WSN in cane sugar cultivation, emphasizing the concept of precision agriculture. The focus of the research is to identify the distance and positioning of network components so as to reduce the number of elements that can ensure greater coverage of the network, maintaining a proper functioning of this type of application. They show that the cane sugar cultivation performance of a WSN with star topology in the drainage layer and sensor nodes is greater than the mesh topology.

There are various special purpose systems involving

the monitoring of climate changes and time. However, most of these systems and equipment are expensive, which usually precludes their use on a large scale. Furthermore, most systems and equipment for this purpose is imported, which further hinders its insertion into everyday applications. The authors in [7] describe the development, design, testing and implementation of a network with low-cost wireless sensors for real-time monitoring of temperature, relative humidity and atmospheric pressure. The network consists of four sensor nodes and a coordinator node. The sensor nodes have a temperature and humidity sensor and a barometric pressure sensor with a digital interface, a low-power micro-controller, and a communication module. The coordinator node further has a communication module for connecting the wireless network, a micro-controller, a memory card for storing information of each sensor node, and an Ethernet interface to provide the sensor measures on a web page, accessed through an IP static in a common web browser. Their laboratory and field tests attest the autonomy of sensor nodes (around 90 days with a 500 mAh battery) and range (approximately 150m on-site) and confirm the compliance of the measured values for each node.

The authors in [11] propose the idea of event-driven type, simulation-based core agents. They exploit the basic model synchronization by barriers, whose features were expanded to include timing and interruption of synchronization events. They propose a framework which can be used in the development of the event-driven simulators with various applications. In addition, they also develop a simulator with a specific application in WSNs, which allows the behavioral modeling of its elements such as the properties of the sensors, the features transmission and reception of loads and batteries.

Due to the constraints of limited processing power, transmission range, small memory, and limited battery in wireless sensors networks, most secure solutions for wired networks, such as based on pure ICP, do not apply directly in this type of environment. The authors in [1] present a hybrid protocol that addresses the key management scheme and the transparent interconnection of clusters. It also addresses the capture issue, offering a solution to the group of key protection. The results show that by increasing the number of sensors in the network, the communication performance between any two clusters remains same.

Another work [3] in this domain deals with the problem of determining the location of sensors in a WSN by a completely decentralized algorithm called HECOPS where each sensor estimates its own position after interacting with other sensor network. A confidence level of ranking system on the estimated position of each sensor is also proposed. The experiments conducted in a simulated environment show that the algorithm outperforms a previous model in terms of accuracy and robustness.

In WSN, merging data with time constraints can be used to generate global network visions and even compensate for the low reliability of individual nodes. However, the nodes of a network with a large number of nodes should be able to self-optimize and self-organize without the interference of human operators. The authors in [6] present several autonomic approaches to QoS assurance in WSN with data fusion applications with time constraints. One of the autonomic approaches uses a machine learning algorithm based on genetic algorithms. These algorithms are inspired by the theory of natural selection and can optimize parameters such as communication efficiency even in multi-objective optimization problems. Since these approaches were modeled to operate at the application layer of compatible devices with the IEEE 802.15.4 standard, it becomes easy to implement in commercially available devices. This technique delivers far superior performance than that of IEEE 802.15.4 protocol.

The real experiments in WSN allow researchers to obtain more accurate results compared to simulations. This can be applied, for example, to understand and evaluate new MAC protocols, routing algorithms as well as link quality estimator. However, the actual experiment requires the use of appropriate test beds. For this reason, the authors in [5] propose a new test bed to conduct experiments in WSN to evaluate link quality estimators. Their test bed consists of the hardware components available in the market to carry out experiments and collect data, and a software tool to track and analyze experiments. Their results are of fundamental importance for creating a new link quality estimator in the context of the related work.

Some approaches [13] [14] in this context use a communication technique for controlling the likelihood of transmission of IEEE 802.15.4 nodes with a view to merging parallel data in a WSN. The goal is to adjust the number of messages sent by the sensors, establishing a compromise between reducing message traffic and ensuring that a sufficient number of messages reach the data fusion center. This number of messages must ensure that the fusion center runs the algorithm with a certain degree of reliability. To validate this technique, a hardware-software framework is developed in order to obtain a better energy performance. The experiments show that the proposed technique can significantly increase the network lifetime. The

results also show the effectiveness of this technique particularly for monitoring the environments with redundant information.

The communication between sensor nodes is the basic element of the operation in a WSN. Therefore, the authors in [18] focus on two key issues for network protocols improvement. First, architecture for routing protocols with service quality assurance is proposed in the scope of mobility scenario. The proposed protocol uses metrics for decision making to relay messages that reflect the network conditions. The communication protocol is evaluated from the perspective of an application scenario involving mobility and different loads messages. In addition, the metrics are aggregated and analyzed to verify their influence on different network conditions. Secondly, the connectivity is studied in its essential feature that refers to the link between two mobile nodes. Two models are designed to provide an estimate of connectivity through the link quality for protocols and applications. The first proposed model is based on the statistical behavior of the mobility patterns to make an estimated link quality. The second proposed model is based on the classification system learning method to learn the mobility pattern of behavior. Both models are implemented and tested with different mobility patterns.

WSNs have shown an increasing penetration in different areas with the emergence of several specific standards with special emphasis on the IEEE 802.15.4 standard [19] [20]. The industrial environment has two characteristics that differentiate it from other application of WSN environments: (i) real-time requirements in the messaging, and (ii) high electromagnetic noise ratio that causes high number of lost messages. Therefore, maximizing reliability is crucial for the application of WSN in industrial environments. In this context, [21] proposes a new network coding algorithm for opportunistic relay messages, applied to WSNs with IEEE 802.15.4 standard. The authors in [22] use network coding techniques, cooperation and temporal diversity in order to increase reliability in the exchange of messages. The network coding is used in relays for nodes to group a set of messages and relay them. The network coordinator, upon receiving the set of the original and encrypted messages can significantly increase the success rate of incoming messages and thus minimize the energy consumption and the use of the medium on the network. The experimental tests demonstrate the feasibility of network coding in the WSN nodes.

3 Proposed Solution

The aim of the research is to develop a system to monitor the operation of EPS and log alerts in case of any discrepancy or a normal log comparative to set benchmarks. The purpose of developing a monitoring system for EPS is to avoid any delays in complex business operations. This system is a preventive measure to avoid operation failure in complex business environments, i.e. banking, hospitals, manufacturing, service industry, media industry, production areas, etc. There are different components of a monitoring system which include software for logging and storing information and hardware such as sensors, GSM module and computer. The developed monitoring system stores data in MS-SQL Server and its front-end is developed in ASP.Net Framework. Logged data stored in computer software enables the management to identify various issues that arise in EPS and frequency of that problem. It helps the management in decision making, cost reduction, and avoiding irrelevant maintenance. Our experimental framework determines and reduces the risk of operation failure in rolling systems such as production facility, hospitals, airport operations, and banking operations. The idea of developing monitoring system is based on keeping in view the complex operations of the business and requirement for developing a system that reduces the risk of failure compared to existing systems.

We use the following equation for monitoring and logging system,

$$Computerlog = (A + B + C) + (B_{amps} + B_{volts} + B_{load}) + Temp \tag{1}$$

where,

- A = Value of electricity presence, either ON or OFF
- B = Value of UPS presence, either ON or OFF
- C = Value of generator presence, either ON or OFF
- B_{volts} = Current value which is stored in alert message, either a normal reading or generated in case where alert value is under/over parameter set limits.
- B_{volts} = Voltage value which is stored in alert message, either a normal reading or generated in case where alert value is under/over parameter set limits.

- B_{volts} = Load value which is stored in alert message, either a normal reading or generated in case where alert value is under/over parameter set limits.
- $Temp$ = Temperature value which is stored in alerts message, either a normal reading or generated in case where alert value is under/over parameter limits.

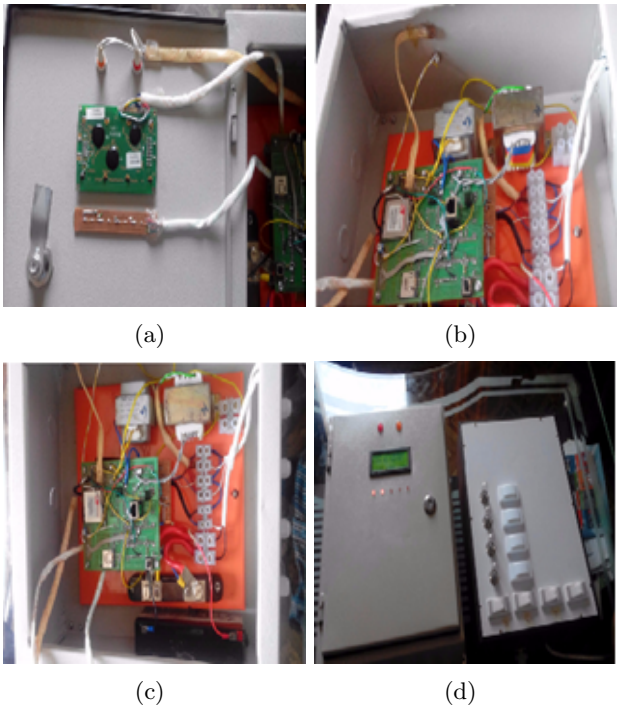
Along with the above-mentioned rules, following criteria is also used for alert generation,

$$Alert\_Message : A + B + \overline{C}$$
$$Alert\_Message : \overline{A} + B + \overline{C}$$
$$Alert\_Message : \overline{A} + B + C$$
$$Alert\_Message : A + \overline{B} + \overline{C}$$
$$Alert\_Message : \overline{A} + \overline{B} + C$$

where, A = electricity ON, $\overline{A}$ = electricity OFF, B = UPS ON, $\overline{B}$ = UPS OFF, C = Generator ON, $\overline{C}$ = Generator OFF
Monitoring and logging system consists of following components:

1) Front-end of the application is developed in ASP.Net Framework.
2) MS-SQL Server is used as database for logged data.
3) Sensors for monitoring current, voltage and room temperature through electronic circuit. Figure 1 shows the diagram of the electronic circuit.
4) USB GSM module is used for sending and receiving text messages / alerts respectively to respective ends in case of any discrepancy. Figure 2 shows the diagram of GSM module and USB modem.
5) Computer for logging and monitoring the status of different parameters such as current, voltage and load of EPS batteries as well as the room temperature. In case of any discrepancy, hardware sensor generates alerts and sends signal from GSM module while the receiver and the GSM module receive the alert and the same will be logged in the system. Figure 3 shows the diagram of the proposed system for monitoring and logging for an Emergency Power System (EPS).

Sensors generate data on different parameters, for example, if room temperature exceeds the set limits, an alert is generated through GSM device/module and it is also logged in the software database through receiving GSM device/module. There are four alert types



(a) (b) (c) (d)

Fig. 1: The electric circut with sensors

having four parameters of each type which include the following.

1) Status of voltage logged in the software is based on alert message which is generated either due to under/over-voltage condition or a schedule alert.
2) Status of current is logged in software is based on alert message which is generated either due to under/over-current condition or a schedule alert.
3) Status of the load on EPS logged in the software is based on the alert message generated either due to under/over-load condition or a schedule alert.
4) status of temperature logged in the software is based on alert message generated either due to under/over-temperature condition or a schedule alert.

Figure 4 shows the flowchart of the monitoring and logging of an Emergency Power System (EPS). There are three master power inputs:

- Grid input: electricity from national grid.
- UPS input: input from emergency power system.
- Genset input: electricity from generator.

Despite the critical alerts, device also generates alerts in case of changes in status of above master inputs.

Fig. 2: GSM Module / USB Modem.

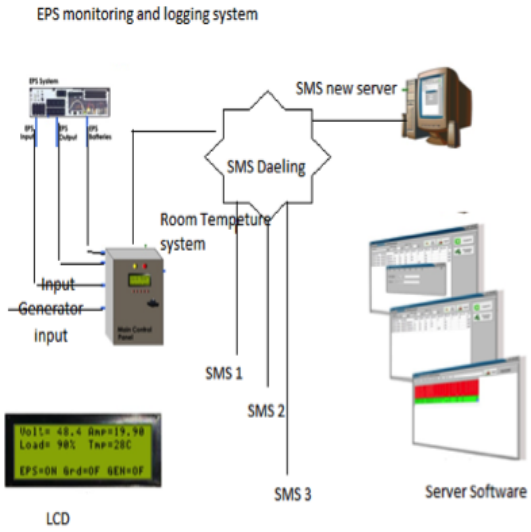


Fig. 3: Workflow for EPS monitoring and logging system.

- Grid On, UPS On and Genset Off
- Grid Off, UPS On and Genset Off
- Grid Off, UPS On and Genset On
- Grid On, UPS Off and Genset Off
- Grid Off, UPS Off and Genset On

The EPS alerts will be stored in Microsoft SQL Server for future use by management through the proposed system. Different reporting formats are also developed in the proposed system for ease of use.

4 Conclusion

In this paper, we proposed a monitoring and logging system for EPS. After testing the proposed system, it is found that the proposed system is helpful in identifying issues before they can occur. The logged data can be used for analysis purposes for preventive

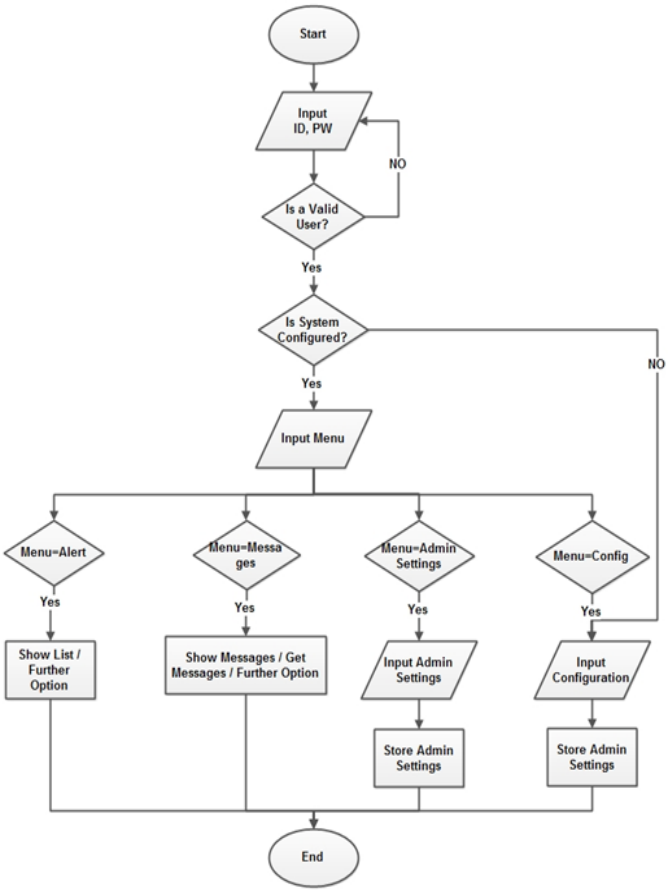


Fig. 4: Flow chart of proposed system.

maintenance, e.g., to determine the best availability for maintenance of EPS. The logged data can also help in further analysis of EPS, which leads to optimize the risk factor and eliminating issues that are critical to EPS.

It is concluded that the monitoring system for EPS helps in reducing risk of operation failure and optimizes preventive maintenance for EPS. After the in-depth analysis, it is found that monitoring systems for EPS can bring significant changes and reduce the risk of operation failure in rolling systems such as production facility, hospitals, airport operations, and banking operations, etc. It is also found that this system is cost-effective for businesses by implementing. In addition to this, rather than hiring a full time personnel for monitoring of EPS, routine tasks can be outsourced which further reduces the overall cost of maintenance.

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Key Security Challenges and Threats to Cyber-Physical Systems and Their Applications

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Abstract

There is a rapid emergence in the field of future technologies and next generation networks (NGN) such as cyber-physical systems (CPS), which are equipped with embedded sensors for monitoring the physical phenomenon and process further for decision making. However, such systems are at constant threat due to inherent uncertainty, context-dependencies, and loss of data packets due to malicious attacks which are causing severe damage to networks. The security of transferred information among different components in cyber-physical systems is vulnerable to the attacks of adversaries who can hijack a physical node to steal all the information. Thus, ensuring the security and early identification of attacks is crucial for cyber-physical systems security. In this paper, we highlight various kinds of security attacks and threats to cyber-physical systems which must be considered while designing a network based on a secure cyber-physical system along with its applications.

Keywords—Cyber-physical systems, security, threats, IoT.

1 Introduction

Cyber-physical systems (CPS) are integration of communication, control and computational components together which form and connect a network between cyber and physical world. The systematic and seamless integration of sensors and actuators make it possible to monitor the physical phenomena from the deployed environment and communicate back to the centralized authority for decision making [1]. The use of Wireless Sensor Networks (WSNs) in the design of cyber-physical systems plays an important role more specifically in the information disseminating stage since secure communication is vital and any breach of data could threaten the whole process of decision making. In addition, the use of cyber-physical systems into various domains, critical infrastructures and applications such as heal-thcare, body area networks, Intelligent Transport System (ITS), security and surveillance systems could have equally catastrophic consequences if security is ignored and there is a lack of appropriate countermeasures. The sensors are small devices with simple deployment scenarios usually in difficult areas where human interaction is hard, thus making them vulnerable to different types of attacks. In addition, the potential use of the cyber-physical sys-tems is also proved by the fact that huge investments are being made by developed nations like the United States and European Union towards the research and development of the CPS [2]- [6]. Moreover, various research initiatives are in progress related to CPS system design, modelling and implementation. Cyber-physical systems applications are used in many disciplines including, energy-sector, Health-care, home appliances, SCADA, manufacturing, intelligent transportation and in environment monitoring. Figure 1 summarizes various applications of cyber-physical systems. Because of the rapid growth in world's population, the security in cyber-physical system becomes a major concern to oversee and steering the individuals in this world. Nowadays, there are a number of technology modes that may have remarkable collision when scheming and executing solutions on cyber-physical infrastructures. One of these impacts is security which is still a big challenge. Cyber-physical systems are the multi-channel, multiplex methodology of a joined-up computing, networks and substantial domain. A Cyber-physical system upgrades the capacity of the system in many facets such as communication in real-time environment, processing of information, self-

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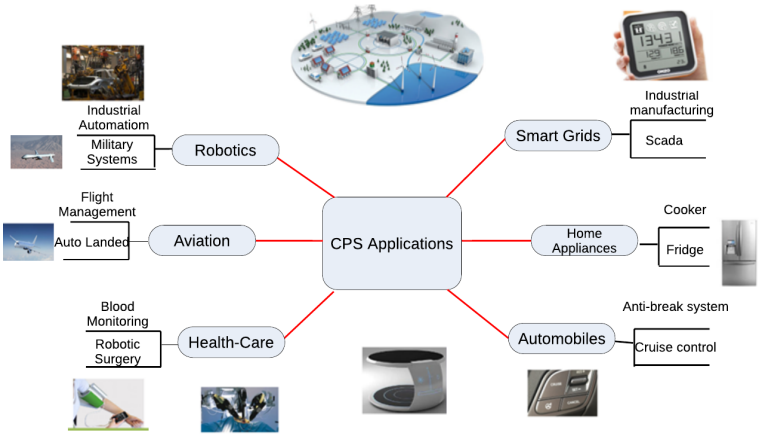

Fig. 1: Applications of cyber-physical systems

supporting of building blocks coordination unit and tangible entities in greatly integrated network domains by mean of string of computation [7]. To provide a secure and trustworthy environment, it is important to detect the attacks early and proper countermeasures must be in in place. In this paper, we analyze various threats and attacks which are aimed to disrupts the operation of cyber-physical system.

The rest of the paper is organized as follows. Section 2 provides various security aspects related to Cyber-physical systems. Sections 3 discusses different attacks related to CPS, while Section 4 describes the security countermeasures and Section 5 discusses the new era of CPS. Finally, Section 6 concludes the paper.

2 Security Aspects In CPS

The basic overflow of any CPS is the monitoring, networking, computing and actuating [8]. Security is one of the issues that is present in all of these processes of Cyber-physical systems. False data may be fed into the system during the monitoring process, the information may be corrupted or blocked at the networking level, the computation process may be attacked to perform malicious controls and calculations and the actuation may be hindered by vandalism of the physical components or the actuators themselves may be physically attacked, as shown in Figure 2. In recent times, there has been a significant increase in attacks against Cyber-physical system. These attacks can massively affect the government, business and other public and private entities as the Cyber-physical system has already started to flourish into every possible field. The reasons behind these attacks may vary, however, some of the major categories of attackers are listed below [9].

1) **Disgruntled employees:** People are the weakest links in the security. More specifically, the unhappy employees can penetrate into the vulnerable parts of the network within the organization and manipulate the processes by misusing the trust and power given to them. This forms one of the most fatal and violated security issues of the current times.

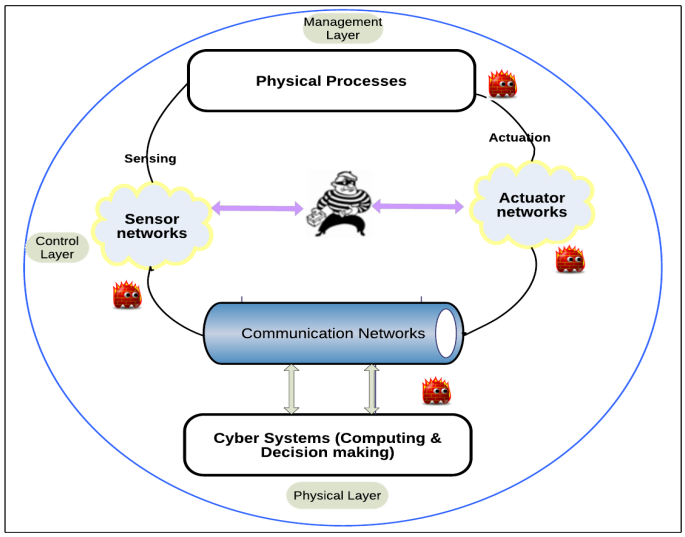

Fig. 2: Security attacks at various layers

2) **Hackers / Cyber-criminals:** These attackers may not be attacking for any specific purpose of harming the system, but only for gaining other insignificant benefits.
3) **Rival governments:** Governments may try to attack other government organizations to gain intelligence, hamper the economic growth, and/or harm the infrastructure, etc.
4) **Other organizations:** Organizations like various groups of terrorists, activists, or criminal gangs can organize a cyber-attack against other organizations for their own respective

reasons.

Some of the consequences of these attacks are data damaging, denial of access, stealing of data, manipulation of data, and manipulation in the sensing and actuating process. Whereas, the other challenges in the cyber-physical systems are inter-operability, efficiency, safety, dependability, sustainability, reliability and predictability [10].

3 Attacks In CPS

Due to the sensing and communication nature of cyber-physical systems (CPS), they are always a target for adversaries which launch different attacks on these systems. Some of these attacks are mentioned as follows.

1) **Denial of Service (DoS):** In this kind of attack, the attacker floods the communication network or the server with huge volumes of traffic or spurious workloads, thus denying service to legitimate users [11] [12].
2) **Man-in-the-Middle (MITM):** This type of attack is classified as active eavesdropping where an attacker initiates and establish a connection with a victim and relays messages. Moreover, the attacker gains the complete control over the victim's conversation.
3) **Time Synchronization Attack (TSA):** The timing information target of a real-time system may be attacked [13].
4) **Routing attacks:** A malicious node in the network can block the network communication path between source to destination and even consume excessive energy.
5) **Malware:** It is a specially created software which exploits the known vulnerabilities in the operating system, hardware and in the protocol. Moreover, a malware enables an automatic and remote management.
6) **Network-based intrusion:** An adversary can penetrate into the existing networks and firewalls through hardware back-doors and exploit the open ports in the software and hardware and even inject the malicious code.
7) **Eavesdropping:** Through some monitoring tools, an adversary can obtain sensitive information or even gain control of the deployed sensor nodes.
8) **Clone attacks:** In a deployed network, an adversary can hijack the physical nodes and replicate the hijacked nodes and then redeploy them back into the existing network. Such attacks are known as clone attacks.

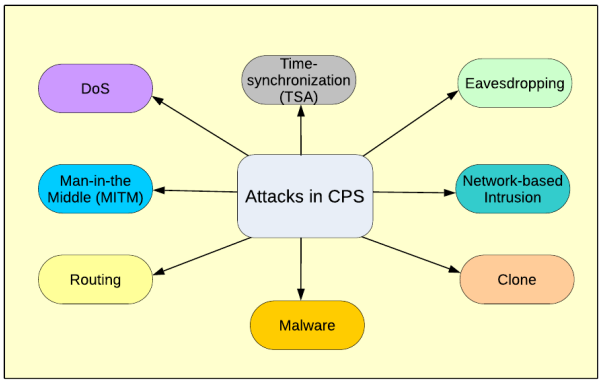

Fig. 3: The taxonomy of CPS attacks

Figure 4 summarizes the taxonomy of the CPS attacks. 2. In addition to the attacks in cyber-physical systems, the following security services are requisite.

1) **Integrity:** The integrity ensures that the message or data is not altered while it is in transit or deliberately tampered by an adversary or through malicious node attacks [14].
2) **Confidentiality:** The confidentiality of the data ensures that the information remain secure from the unauthorized access [14].
3) **Availability:** In an unreliable operating environment, the availability affects the network performance, especially if the network is under a Denial of service (DoS) attack.
4) **Authenticity:** Authenticity validates the participating entities through validation since unauthorized entities affect the network performance.

4 Security Countermeasures

By the discussions in the earlier sections, it is well under-stood that managing the security of cyber-physical systems is not trivial and requires a careful design and countermeasures against well-known threats. Moreover, the implemented countermeasures should have an ability to not only resist the attacks, but also to bring the system back into operational state. The security measures in cyber-physical system can broadly be divided into following categories.

4.1 Prevention

Prevention is based on the manufacturers' understanding of the vulnerabilities within the design of cyber-physical systems and the hardware which includes the various precautionary measures taken to prevent any attack. Similarly, the specific software which is designed only for underlying Cyber-physical system (CPS) also falls in this category.

4.2 Detection

None of the systems are perfectly secure and thus there is always a chance of attack on a deployed cyber-physical system. Therefore, an early detection of attack limits the impact of a damage. In addition, once an attack is detected, appropriate countermeasures must be in place to ensures the system resilience. Some of the countermeasures implemented in the cyber-physical system to obtain better security include the following.

1) **Cryptography:** It is one of the oldest and most implemented methods of securing a system. It involves authentication through security passwords, keys etc.
2) **Remote attestation:** In this technique, a remote device is attested for verifying a node [15]. Attestation can be for both soft-ware and hardware.
3) **Prediction Mechanisms:** The system uses certain algorithms to predict potential attacks, failures or malicious activities and warns accordingly [16].
4) **Trust and reputation:** Using trust and reputation as security measures is a new method which involves lower overhead and computational complexity as compared to the traditional cryptographic security measures. It is a degree of trust which one node has for another. Trust and reputation increases the confidence level of nodes while communicating with other nodes for sharing the data [20].

5 New Era for Cyber-Physical Systems

Internet of things (IoT), is a network of physical objects, usually sensors and actuators, which have sensing and communication capabilities where sensors provide the captured data directly to the application.

5.1 Internet of Thing (IoT)

IoT is a framework which provides distinctive identifiers to individuals or objects and connects them using Internet, enabling data transmission without human interaction. The key challenge for IoT is to create a better world for humans in which entities around us understand our needs and likes [17]. Just like cyber-physical systems, several aspects such as anti- eavesdropping, privacy, encryption, secure point to point connection with authentication request of access control, and approaches which supports security and privacy issues by means of identification and authentication are required to achieve security in a network. The diverse issues are presented in Figure 3. For a secure storage, an instrument is needed which is based on encryption algorithms and which enables the protection of information [18]. Authentication, data integrate, device availability, data secrecy and confidentiality are some of the notable features for effective and secure communication among devices in IoT.

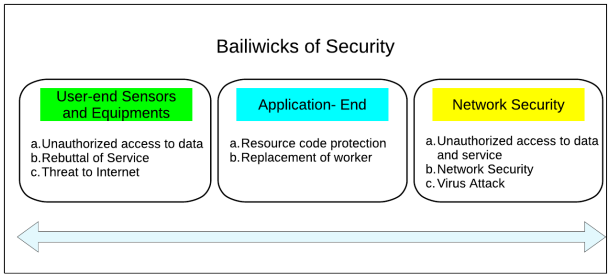

Fig. 4: Security issues in IoT

5.2 Big Data

Big data is a set of huge amount of data which cannot be managed and processed by traditional software tools within an acceptable processing time. Big data refers to all the data which is present in a serverâĂŹs data-base. Nowadays social networks, cloud systems, and smart mobiles are able to process big amount of data which refers to the term Big data [19]. Big data represents a Multi-V mechanism which refers to a huge amount of data (minimum in Terabytes), variety of data by means of different formats, velocity by means of data arrival at a high frequency, and huge number of data source. Because of the low cost, and far-reaching technology, the big data enables new and seamless provocation and possibilities in the area of cyber-physical systems. In cyber physical applications, environment sensors collects data from the physical environment and reports it back to a centralized authority which generates real-time response [20]. Real-time processing of big data has now become a challenge for the applications of cyber-physical systems.

5.3 Cloud Computing

A group of servers and network software that allows centralized database for data storage and online access to online services or resources such as Facebook, Google constitute cloud computing. The terminology of evolution of on-demand information technology services and products refers to the recently introduced technology of cloud computing. Cloud computing provides real-time services, security and protection, solidity, and reliability requirement in cyber physical system. Cyber physical systems require resilience and

auto-scaling capabilities of the cloud platforms as change in the amount of work in done. The use of Smart Networked System (SNS) bridge the gap between the physical and virtual world which interlinks the network of sensors, actuators and processing devices. The SNS concept is based on five technologies including networked system, wireless sensor network, real-time processing systems, social networks and cloud computing [21]. Following are some of the technical challenges for cloud based cyber-physical systems.

- System-wide auto-scaling
- To balance the real-time curb with a cost and other goals, a versatile optimized algorithm is needed.
- To support real-time demand, improve the failover or fault-tolerance.
- An algorithm that depends on the physical properties of the computations is the need for data provisioning and load balancing.

6 Conclusion

Cyber-physical systems are the composition of cyber and physical components which are integrated deeply into all the applications with an ability to process and hold a huge amount of data. Cyber-physical systems are expected to connect possibly everything within a network and use the individual components which not only generate voluminous amount of data, but also require trustworthy transmission and storage. Since the physical components of IoT and the big data requires interconnection and access between each other, it leads to a demand of cloud computing which enables the access to a network. The integration of these three individual fields of information technology further leads to a much more efficient, effective and powerful rise of cyber-physical systems which can have more influence on every field of pervasive computing. In addition, these devices are highly vulnerable to various attacks and threats. Therefore, the design of security countermeasures must be robust against these attacks to make the system highly secure and trustworthy.

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Technique for Tumor Detection Upon Brain MRI Image by Utilizing Support Vector Machine

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Abstract

Medicinal images assume a key part in the diagnosis of tumors. In a similar way, MRI could be the cutting edge regenerative imaging technology which permits corner sectional perspective of the body, facilitating the specialists to inspect the affected person. The detailed MRI images enable the medical specialists to recognize minor improvements of structures throughout the body, and serve as a basic part in finding and treatment planning. In this paper, we address the issue of classifying a brain MRI image to predict whether it contains a tumorous part or not. We utilize Histogram of Oriented Gradients (HoG) features to train a Support Vector Machine (SVM) to efficiently predict an MRI image to contain a tumorous part. Before applying the trained SVM classifier on the test MRI images, we also perform image enhancement to increase the accuracy of the prediction. Our experimental results show an impressive accuracy of the proposed technique.

Keywords—Brain Tumor, Magnetic Resonance Image (MRI), Image Enhancement, Image segmentation, SVM (support vector machine), Feature Extraction, HoG (Histogram of Oriented Gradients).

1 Introduction

Brain tumor acknowledgment with magnetic resonance images (MRI) is critical in the medicinal determination as it gives organized information on the design outline of a body part. Medical imaging is really a crucial segment connected with countless which helps to conclude. The best component of MRI is that it can create images of diverse features. There are a couple of essential MRI checks out: (i) T1 weighted MRI, and (ii) T2 weighted MRI. T1 images are generally used to take a gander at typical anatomical subtle elements. T1 is suitable for looking at the cerebrum structure on the grounds that fats and tissues seem brilliant and bone marrow contains a lot of fat. T2 is the transverse development of protons and is typically used to take a gander at pathology in the light of the fact that most tissues included in contagion have a tendency to have higher water content than normal. T1 and T2 checkouts have following effects.

- White matter appears light gray in T1, and dark gray in T2.
- Grey matter appears grey in both.
- Cerebrospinal fluid (CSF) appears black in T1, and white in T2.

As we are concentrating on the tumorous area, T1 weighted MRI outputs are most useful for us as they can help us in examining the points of interest of anatomical conduct of tumorous region. Therefore, we utilize T1-weighted images for preparing our model. MRI is one of the most effective diagnostic techniques in medical imaging technology which permits the cross-sectional perspective of the body with uncommon tissue contrast [1]. MRI assumes a vital part in evaluating neurotic states of the lower leg, foot and cerebrum. Additionally, MRI is a non-obtrusive methodology that has been proven to be very instrumental in the investigation of the human cerebrum. The data that MRI gives has enormously expanded information about the ordinary and diseased anatomy about medical research, and is a basic part in the diagnosis and treatment of a disease [2]. A doctor's choice of medicinal treatment depends on the diagnosis

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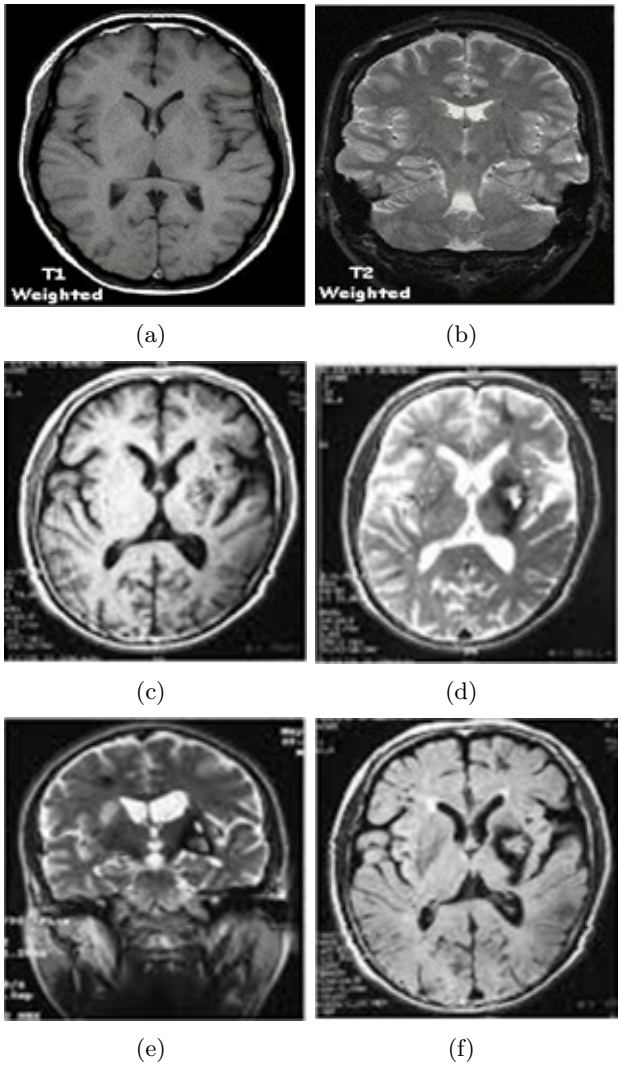


(a) (b)

(c) (d)

(e) (f)

Fig. 1: T1 weighted MRI scans (a, c, e), and T2 weighted MRI scans (b, d, f)

tests. Hence, the precision of an analysis is key in medical care. Fortunately, the properties of the conclusion tests can be measured. For a given disease condition, the most ideal test can be picked in view of these properties. The affectability, specificity and precision are widely used in a demonstrative test. Figure 1 shows the comparison between T1 and weighted MRI scans and T2 weighted MRI scans.

1.1 Tumour Detection in Brain MRI Images

The brain is a soft, spongy mass of tissues which is covered by skull, a hard bone, three thin layers of tissue called meninges, and a watery fluid. The brain is responsible for all the major actions that a human body requires, e.g., thinking, walking, talking, etc. It is also controlled by our senses such as sight, hearing, touching, taste, smell, memory, emotions and personality. Brain has the following three major parts.

1) **Cerebrum** conveys information between the brain and other parts of the body through nerves. It is also responsible for reading, thinking, learning, speech and emotions.
2) **Cerebellum** is responsible for balance, walking standing and other complex actions.
3) **Brain stem** connects the brain with the spinal cord. It controls breathing, body temperature, blood pressure, and other basic functions.

Computer-aided detection of anomalous development of tissues is essentially persuaded by the need of accomplishing most possible accuracy [3]. Most of the cells in the body are generated and then divided in an orderly way to produce further cells in order to keep the human body healthy and working properly. When cells lack the ability to grow or divide evenly, the extra cells produce masses of tissue known as tumor. According to medical science, tumor are of two types: benign and malignant.

1.2 Benign Brain Tumours

This type of tumor does not contain cancer cells. Normally benign tumours can be removed and they seldom re-grow. The border or edge of a benign brain tumour can be clearly seen. Cells from benign tumours do not invade tissues to other parts of the body, but they are also dangerous because they can press on the sensitive areas of brain and make brain to work improperly and cause serious health issues. Very rarely, a benign brain tumor may become malignant.

1.3 Malignant Brain Tumor

Malignant brain tumors is serious and life-threatening for patients. It may be primary (a tumour that mainly originates from the brain tissues) or secondary (metastasis that originates from another part of the body). In both cases, it is likely to grow fast and can invade the surrounding normal brain tissues.

A brain tumour is one of the real reasons for the increase in mortality rate among kids and adults. A tumor is a mass of tissue that becomes uncontrollable by the typical forces that trigger its development [4]. The rate of brain tumor is rapidly increasing, especially in older people than younger once. A brain tumor is an accumulation of anomalous cells within the brain or around the cerebrum. Tumor can specifically crush all healthy brain cells. It can also affect the healthy cells around the tumorous one and affect different parts of the brain by creating inflammation, swelling and generating pressure inside of the skull [6].

Early location and right treatment taking into account precise conclusion are essential strides to enhance the results of diagnosis. Brain irregularities include a wide range of conditions extending from development mistakes to vascular mishaps. This variability results in incalculable potential outcomes of discoveries of prenatal ultrasound, which could make some analytic predicaments.

2 Literature Review

The research on tumour detection is becoming increasingly popular and important these days due to its appealing prospects for analyzing tumour growth history and morphological alterations in the cancer operation [1] [3] [4]. Early tumour detection in brain is particularly important due to the alarmingly high mortality rate caused by brain tumour all over the world [1].

For automatic detection of brain tumours, the widely used techniques are based on traditional image processing. The techniques for tumour detection using image processing studied in the literature can be broadly categorized as automatic and semi-automatic. However, the performance of these techniques usually remains limited due to a number of factors and/or constraints. Some of these factors include presence of noise in input images, poor contrast of images, and occlusions, etc [2] [4] [5].

Scientists have applied different approaches in order to propose an efficient system that can detect a tumor from brain images in which MRI has the best image results. These approaches are proposed for MRI image segmentation such as statistical methods using pixel labeling, threshold based methods, and parametric techniques, to name a few [7] [8] [9]. These strategies name pixels according to the likelihood values, which are resolved according to the intensity distribution of the image.

Varying intensity of tumours in cerebrum MRIs makes the cerebrum of such tumours tremendously difficult. Cerebrum tumour division utilizing an MRI has been extensively researched. Both elements-based and chart book based techniques and also their blends have been proposed for cerebrum tumour division. The authors in [1] state that brain segmentation is computerized utilizing a dual localization strategy. In the initial step of their procedure, scull veil is produced for the MRI images. White matter and tumor area are utilized to ad lib K-implies algorithm. In the last stride of their strategy, they evaluate the breadth and length of the tumor [5]. MRI is valuable for analyzing cerebrum images due to its high precision rate. This technique combines the clustering and arrangement algorithm to minimize the error rate. Segmentation errand is performed utilizing the ortho-normal administrators and characterization utilizing BPN. Images containing a tumor are prepared to utilize K-implies grouping and a precision rate of 75% is acquired [6].

The authors in [7] argue that the segmentation results will not be accurate if the tumor edges are not sharp, and that this case emerge amid the underlying phase of a tumor. A texture-based strategy is proposed in this paper. Alongside cerebrum tumour location, segmentation is likewise done automatically utilizing this technique. In another technique [8], the authors propose a proficient strategy for cerebrum tumour identification. A standout among the most critical strides in tumour discovery is segmentation. A mix of two standard algorithms, first means move and second standardized slice is performed to identify the brain tumor surface zone in MRI. By utilizing a mean move algorithm, a pre-handling step is performed with a specific end goal to shape fragmented districts. In the following stride, district hubs clustering is prepared by the standardized cut strategy. In the last stride, the cerebrum tumour is distinguished through segment investigation.

The authors in [9] propose a programmed brain tumor detection approach utilizing symmetry examination. They first distinguish a tumor, section it and afterwards discover the region of the tumor. One of the vital elements is that subsequent to playing out the quantitative examination, we can distinguish the status of an expansion in the ailment. They recommend a multi-step and secluded drew closer to take care of the intricate MRI division issue. The tumor discovery is the initial step of tumor division. They obtain better results in complex scenarios.

Another approach primarily comprises of four stages: i) Pre-processing, ii) isolation of an area utilizing crop tool, iii) feature extraction of the district by utilizing HoG include, and iv) final grouping utilizing the support vector machine. In the pre-handling stage, channels are utilized to remove picture commotion in the MRI images.

The recent work has focused on machine learning for tumour detection in MRI images due to the growing popularity of machine learning. The authors in [14] first segment image using a pulse-coupled neural network. This is followed by the feature extraction using discrete wavelet transform. Subsequently, a neural network classifies the input image into with or without tumour. In a more recent work [15], the authors use deep neural network architecture utilizing small kernels for tumour segmentation in MRI images.

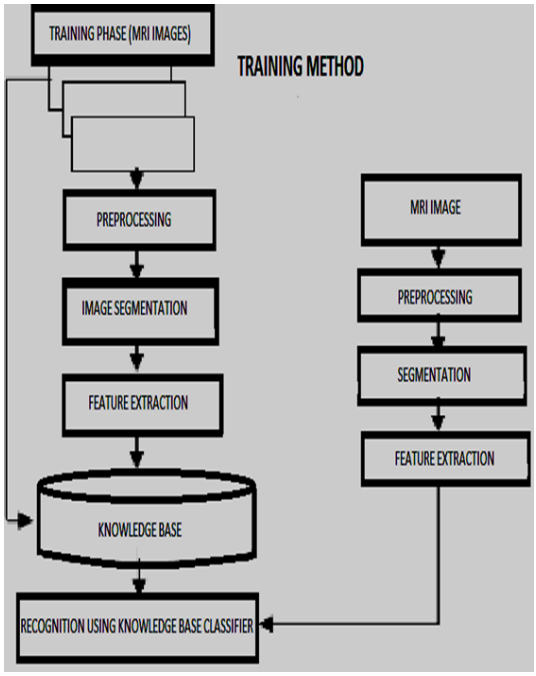


Fig. 2: Proposed methodology for tumor detection in a brain MRI image

2.1 Proposed Technique for Tumor Detection

Our proposed technique is summarized in Figure 2. The individual steps of the proposed technique are explained in the following sections.

2.2 Pre-processing

A few pre-processing steps are utilized to concentrate more on the correct components from MRI images. We utilize dark MRI images so that we can smooth them by an alteration in contrast for better results.

2.3 Image Enhancement

Image enhancement is the procedure of adjusting digital images so that the resulting images are more suitable for further diagnosis. Nowadays, research on tumor has immense focus on account of their potential for separating past advancement arrangements and morphological changes in the development operation [1] [3] [4]. An early area of a tumor in the cerebrum is significant as the death rate is more obvious among individuals actuating brain tumour [1]. Brain tumor area techniques use image processing that has present for recent decades. A couple of researchers have presented systems of modified and semi-automatic image processing approaches to detect tumours regions in cerebrum in which most of the frameworks disregard to deal with the expense of capable and effective results owing to the region of image noise, inconsistency, and low-quality that generally occur in medical images [2] [4] [5]. A number of techniques have been proposed to distinguish a tumour from cerebrum image, among which the techniques working with MRI are shown to be most effective. Most of the techniques prefer to label pixels. Whereas the techniques utilizing edge systems and parametric systems are rarely used [7] [8] [9]. These strategies label pixels based on their probability values which are determined on the premise of power dissemination. Some of them include removing noise from the image, and envisioning the brain cortex territory in MRI images [10]. The particular dark ranges encompassing the brain are removed from the image-enhanced method [11] [12] [13].

2.4 Feature Extraction

After enhancing and adjusting images and selecting the positive and a negative region from MRI image separately, we extract Histogram of Oriented Gradients (HoG) feature of selected regions and label our regions as positive or negative. We then pass the feature vectors to SVM to train our model. Feature extraction is among the most critical steps while we are distinguishing or separating particular region from our image. There are numerous algorithms relying upon the type of features. We implement HoG features to identify the elements of our region of interest. Histogram of Oriented Gradients can be used for object recognition in an image [16]. We apply them so as to attempt to distinguish tumor region in brain cortex. HOG baed object detection is a procedure in which an image detector ïňĄnds image features and decides the location of objects of interest in the image.

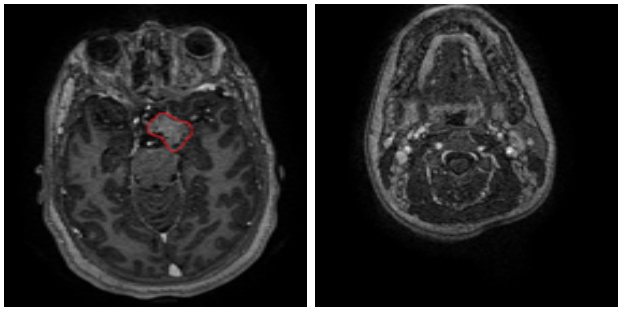
2.5 Classification Using SVM

We train a classifier using Support Vector Machine (SVM) on the training data. The trained classifier is able to classify the brain MRI images as having tumor or not. SVM classifiers are known to solve the 2-class problems effectively. After extracting the HoG features of the region of interest from all the MRI images, we train them using SVM algorithm.

Figure 3a shows an MRI image from our training dataset. It can be seen that the tumorous part is marked as a region of interest. Figure 3b shows an example of an MRI image which has to be tested by the trained SVM classifier.

3 MRI Image Dataset Description

The MRI image dataset that we use in our work is divided in the following two categories.



(a) (b)

Fig. 3: MRI image of (a) training dataset, and (b) test dataset

3.1 Training Dataset

Training dataset is gathered from the publicly accesible online source (www.radiopedia.org) of MRI images with and without tumors that we utilize for training our proposed model. We take about 10 tumorous MRI images for training.

3.2 Testing Dataset

As we are keen to implement our model in a real environment, thus we test our model on a dataset that we have collected from a renowned hospital in Karachi. We acquired the data of seven patients suffering from brain tumor.

4 CONCLUSION

In this paper, we proposed a technique for tumor detection in brain MRI images. It is not trivial for a common man to detect the tumor region easily just by viewing MRI images as Pathologists and MRI technicians are able to judge the tumor area by doing a comparative analysis of an image. We connected characteristic extraction strategy by applying HoG feature to train a SVM classifer to predict the probability of an MRI image having tumor. Our proposed system is further able to detect the correct tumorous region that is also highlighted by a pathologist.

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