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Statistical Approach to Estimate the Weather Prediction

Arindam Roy[1*], Dharmpal Singh[2], Sudipta Sahana[3], Ira Nath[4]

[1,2,3,4]Dept. of Computer Science & Engineering JIS College of Engineering, Kalyani, Nadia-741235

*Corresponding Author: arindamroy.roy35@gmail.com, Tel.: +91-7003766269

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Abstract**—** The burgeoning research in the fields of statistical has given rise to numerous weather prediction models. But the problem of accurately predicting or forecasting the weather still persists. Numerical weather prediction is taking the existing numerical data on weather conditions and applying machine learning algorithms on it to forecast the weather. If the assessment of weather cannot be selected properly, the prediction information becomes incorrect and this will create lots of the problem in the real life. Therefore selection of an appropriate technique for the purpose of forecasting is needed. Here the effort is to select the soft computing technique properly for the prediction of the futuristic annual average Temperature of India. Initially, the concepts of least square base linear equation, exponential, asymptotic , curvilinear , logarithm have been applied to optimize the error and the concept of soft computing model will be used for the further enhance of the error. Moreover, the same concept has been applied on the tested data to select the optimality of the model predicted model.

Keywords**—** Soft Computing, Least Square Base Linear Equation, Weather prediction

I. INTRODUCTION

Weather forecasting means predicting the weather conditions (conditions of atmosphere) of a particular given area or location. Accurate weather prediction is very important to pursue day-to-day activities. Living and non-living things are dependent on weather predictions.

The weather forecasting industry in India facing many obstacles is still in its initial stage,. One of the major obstacles is the arbitrary & ill-suited expectations from the nature. Numerical Weather Prediction (NWP) is one of the popular and widely used prediction model that takes the present weather conditions and processes it to build a model for predicting the weather.

Several data mining techniques have been employed in diversified applications such as predicting rainfall, weather, storms and flood. Weather forecasting falls under predictive mining which focuses on the data analysis, formulates the database, and forecasts the features of anonymous data.

Solving the weather prediction obstacles and in-efficiency based on linear regression algorithms through normal equation model is the focus of this research work. The major contribution is to formulate an efficient weather prediction model based on the linear regression algorithms. Thus, this work uses normal equation model's hypothesis and compares it with the gradient descent model in order to overcome the limitations of the weather prediction. Even though, gradient descent is considered as the widespread approach among the linear regression algorithms, this research work is based on normal equation algorithm to predict the future weather conditions. With this research, weather can be forecasted with greater accuracy, which will be helpful in daily activities.

II. METHODOLOGY

2.1 Least square regression based linear equation

Least square technique based on linear regression is a technique which can predict the value of a dependent variable *Y*, based on the value of an independent variable *X*. All control parameters (independent variables) remain constant, the resultant outcome (dependent variable) varies. In regression analysis, curve fitting is the process of specifying the model that provides the best fit to the specific curves in your dataset. Nevertheless, the fitting curve of a given given set of data, is *not unique* generally. Thus, a curve with a minimal deviation from all data points is desired. Least Square method gives *best-fitting curve*. The least squares method assumes that the best-fitted curve of a given data is the curve that has the minimal sum of the squared deviations *(least square error*) from a given set of data.

2.1.1 Prerequisites for Regression

For appropriate linear regression the following conditions are required to be satisfied.

(1) The dependent variable *Y* has a linear relationship to the independent variable *X*. To check this, it is necessary to make sure that the XY scatter plot is linear and that the residual plot shows a random pattern.

(2) For each value of X, the probability distribution of Y has the same standard deviation σ for same number of terms from different places of the available data. When this condition is satisfied, the variability of the residuals becomes relatively constant across all values of X, which can be easily checked in a residual plot.

(3) For any given value of X, the following techniques have to be followed:-
(a) The Y values are independent, as indicated by a random pattern on the residual plot.
(b) The Y values are roughly normally distributed (i.e., symmetric and unimodal). A little skewness is allowed if the sample size is large. A histogram or a dot plot shows the shape of the distribution. [22]

2.1.2 The Least Squares Regression Line

Least squares regression line or LSRL that represents best observations in a bivariate data set is a straight line. Suppose *Y* is a dependent variable, and *X* is an independent variable. The population regression line is:-

$$Y=C_0+C_1X$$

where C_0 is a constant, C_1 is the regression coefficient, X is the value of the independent variable, and Y is the value of the dependent variable.

For a given a random sample of observations, the population regression line is estimated by:

$$\hat{y} = c_0 + c_1x$$

where c_0 is a constant, c_1 is the regression coefficient, x is the value of the independent variable, and is the *predicted* value of the dependent variable.

Let the equation be

So, $\sum y = \sum a + \sum bx$

$$\sum y = na + \sum bx \qquad ....(1)$$

[Where n =number of terms]
Again

$xy = ax + bx^2$ [Multiplied both sides by x]

so,

$$\sum xy = \sum ax + \sum bx^2 \qquad ……………….(2)$$

if x in chosen in such a way that $\sum x = 0$

then , $a=\frac{\sum y}{n}$

and

$$b=\frac{\sum xy}{\sum x^2}$$

Putting the values of a and b in equation $y = a + bx$ the equation of straight line becomes,

$$y=\frac{\sum y}{n}+\frac{x*\sum xy}{\sum x^2}$$

For different values of x, the different values of y have been calculated.

Due to size of the paper, other methods have not discussed here.

III. PROPOSED WORK

To predict futuristic forecasted data, regression analysis using least square technique based on Linear equation, Exponential equation, Asymptotic equation, Logarithmic equation, curvilinear (parabolic) equations have been used. Along with that the fuzzy logic and neural network can be used to estimate data for further optimization.

IV. IMPLEMENTATION

The available Average Annual Temperature of India from previous 115 years have been collected (Table 1) and using these, the prediction of Annual Average Temperature for futuristic years has to be ascertained using least square base linear equation technique. Minimum average error has been selected for the prediction.

Table 1 (115 Years Temperature Dataset)

YEAR	JAN-FEB	MAR-MAY	JUN-SEP	OCT-DEC	ANNUAL
1901	18.71	26.06	27.3	21.92	24.23
1902	19.7	26.44	27.18	21.49	24.33
1903	19.05	25.47	27.17	21.27	23.8
1904	18.66	25.84	26.83	21.42	23.86
1905	17.58	24.99	27.37	21.48	23.71
1906	18.37	25.93	27.15	22.08	24.12
1907	19.35	24.89	26.89	21.76	23.87
1908	19.04	26.02	26.95	21.17	23.95
1909	18.42	25.71	26.53	21.75	23.78
1910	18.93	25.74	26.81	20.96	23.77
1911	18.85	25.53	27.18	21.48	23.96
1912	19.72	25.81	27.13	21.29	24.11
1913	19.09	25.56	26.93	21.32	23.88
1914	19.31	25.53	27.15	21.52	24.03
1915	18.47	26.03	27.6	22.01	24.29
1916	19.1	26.41	26.92	21.27	24.08
1917	19.05	24.89	26.75	21.01	23.56
1918	18.4	25.39	27.07	21.54	23.83
1919	18.96	25.85	27.06	21.48	24.01
1920	18.72	25.27	27.05	21.85	23.91
1921	19.06	26.6	26.99	21.39	24.33
1922	19.4	25.88	27.07	21.2	24.05
1923	18.8	26.12	27.11	21.4	24.05
1924	19.02	26.14	27.18	21.52	24.15

1925	18.31	26.18	26.92	21.51	23.95
1926	19.68	25.28	27.41	21.26	24.04
1927	18.77	25.51	26.98	21.76	23.94
1928	19.39	26.19	27.18	21.81	24.29
1929	18.62	26.36	27.1	21.42	24.08
1930	18.23	25.81	27.04	21.71	23.93
1931	19.54	26.36	27.29	21.97	24.44
1932	19.12	25.91	27.32	21.75	24.21
1933	19.1	25.34	26.87	21.77	23.92
1934	19.15	25.89	27.29	21.55	24.13
1935	18.62	25.77	26.96	21.65	23.98
1936	19.03	26.02	26.94	21.86	24.12
1937	19.11	25.61	27.32	21.14	23.98
1938	18.46	26.5	26.86	21.31	23.98
1939	19.1	25.41	27.16	21.67	24.01
1940	19.03	25.49	27.08	21.91	24.06
1941	19.31	26.87	27.45	22.3	24.65
1942	19.07	26.49	27.18	21.72	24.22
1943	18.89	25.57	26.97	21.68	23.93
1944	18.54	25.7	27.27	21.76	24.03
1945	18.35	25.71	27.43	21.16	23.92
1946	19.52	26.12	27.24	22.13	24.42
1947	18.78	26.42	27.32	21.39	24.04
1948	18.83	26.04	27.08	21.73	24.11
1949	19.18	26.14	27.08	21.29	24.08
1950	18.71	25.5	26.87	21.14	23.71
1951	18.68	25.47	27.19	22.45	24.22
1952	19.86	26.04	27.25	21.77	24.34
1953	19.47	26.87	27.33	22.01	24.57
1954	19.11	26.5	27.09	21.15	24.13
1955	19.46	25.58	26.98	21.35	23.97
1956	18.83	26.31	26.66	21.41	23.96
1957	18.73	25.25	27.15	21.94	23.97
1958	20.01	26.45	27.43	22.13	24.62
1959	18.93	26.31	27.19	22	24.3
1960	19.72	25.7	27.34	21.84	24.29
1961	18.98	26.11	27.06	21.17	24
1962	18.91	25.91	27.14	21.47	24.04
1963	19.07	25.57	27.21	22.04	24.15
1964	18.83	26.38	26.9	21.58	24.1
1965	19.22	25.24	27.08	22.1	24.07
1966	19.93	26.07	27.17	21.83	24.36
1967	19.44	25.55	27.19	21.68	24.11
1968	18.25	25.62	27.22	21.69	23.94
1969	19.18	26.39	27.35	22.2	24.46
1970	19.56	26.39	27.06	21.55	24.26
1971	19.05	25.78	26.75	21.48	23.91
1972	18.57	25.78	27.27	21.88	24.1
1973	19.74	26.53	27.3	21.53	24.41
1974	18.54	26.24	27.02	21.38	24
1975	18.69	25.77	26.57	21.3	23.74
1976	18.87	25.61	26.87	22.25	24.07
1977	19.35	26.03	27.13	22.3	24.35
1978	18.95	25.94	27.12	22.22	24.24
1979	19.47	25.97	27.54	22.59	24.57
1980	19.64	26.58	27.26	22.17	24.55
1981	19.42	26.14	27.22	21.68	24.27
1982	19.14	25.41	27.31	22.02	24.15
1983	19.09	25.45	27.43	21.71	24.12
1984	18.85	26.51	27.1	21.82	24.26
1985	19.61	26.72	27.12	21.84	24.45
1986	19.12	25.94	27.17	21.9	24.2
1987	19.42	25.85	27.88	22.29	24.57
1988	19.7	26.24	27.22	22	24.42
1989	18.76	25.69	26.98	21.94	24.03
1990	19.44	25.55	27.18	22.11	24.21
1991	19.21	26.02	27.32	21.87	24.28
1992	19.06	25.64	27.15	22.04	24.15
1993	19.61	25.98	27.34	22.21	24.43
1994	19.76	26.3	27.3	21.97	24.46
1995	20.33	26.94	28.07	23.19	25.29
1996	20.79	26.49	27.22	21.76	24.55
1997	18.87	25.69	27.6	21.89	24.1
1998	19.72	26.41	27.69	22.42	24.76
1999	19.75	26.66	27.38	22.29	24.67
2000	19.33	26.47	27.23	22.68	24.6
2001	19.75	26.82	27.47	22.52	24.73
2002	19.65	27.22	27.71	22.58	25
2003	19.82	26.52	27.64	22.23	24.72
2004	19.93	27.06	27.33	22.24	24.74
2005	19.79	26.33	27.64	21.93	24.58
2006	21.33	26.52	27.4	22.66	25.06
2007	20.1	26.69	27.49	22.32	24.77
2008	19.16	26.46	27.26	22.87	24.61
2009	20.72	26.86	27.89	22.58	25.11
2010	20.19	27.83	27.5	22.6	25.13
2011	19.54	26.38	27.54	22.71	24.67
2012	19.34	26.55	27.71	22.35	24.69
2013	19.98	26.85	27.46	22.5	24.82
2014	19.58	26.24	27.88	22.47	24.73
2015	20.12	26.29	27.73	22.99	24.91

4.1 Statistical Model using Least Square Technique

Based on the Linear equation, exponential, asymptotic , curvilinear , logarithm equations , the estimated values and relative error have been calculated. The average error f o u n d a s 0.049% 0.55%, 0.051%, 0.54% and 0.055% respectively. Linear Equation shows a minimum error that means the technique is acceptable for the prediction of Temperature. Now an effort is being made to make a prediction of futuristic years for testing purpose. Result has been furnished in Table2.

Table 2 (Estimated Annual Average Temperature)

YEAR	JAN-FEB	MAR-MAY	JUN-SEP	OCT-DEC	Estimated ANNUAL Temperature	Estimated ERROR
1901	18.64	25.53	26.63	21.92	23.84583333	-1.5855
1902	18.65	25.54	26.64	21.49	23.74583333	-2.40101
1903	18.66	25.55	26.65	21.27	23.69833333	-0.42717
1904	18.67	25.56	26.66	21.42	23.74333333	-0.48896
1905	18.68	25.57	26.67	21.48	23.76583333	0.235484
1906	18.69	25.58	26.68	22.08	23.92333333	-0.81537
1907	18.7	25.59	26.69	21.76	23.85083333	-0.0803
1908	18.71	25.6	26.7	21.17	23.71083333	-0.99861
1909	18.72	25.61	26.71	21.75	23.86333333	0.350435
1910	18.73	25.62	26.72	20.96	23.67333333	-0.40668
1911	18.74	25.63	26.73	21.48	23.81083333	-0.62257
1912	18.75	25.64	26.74	21.29	23.77083333	-1.40675
1913	18.76	25.65	26.75	21.32	23.78583333	-0.39433
1914	18.77	25.66	26.76	21.52	23.84333333	-0.77681
1915	18.78	25.67	26.77	22.01	23.97333333	-1.30369
1916	18.79	25.68	26.78	21.27	23.79583333	-1.18009
1917	18.8	25.69	26.79	21.01	23.73833333	0.756933
1918	18.81	25.7	26.8	21.54	23.87833333	0.202826
1919	18.82	25.71	26.81	21.48	23.87083333	-0.57962
1920	18.83	25.72	26.82	21.85	23.97083333	0.254426
1921	18.84	25.73	26.83	21.39	23.86333333	-1.91807
1922	18.85	25.74	26.84	21.2	23.82333333	-0.94248
1923	18.86	25.75	26.85	21.4	23.88083333	-0.7034
1924	18.87	25.76	26.86	21.52	23.91833333	-0.95928
1925	18.88	25.77	26.87	21.51	23.92333333	-0.11134
1926	18.89	25.78	26.88	21.26	23.86833333	-0.71409
1927	18.9	25.79	26.89	21.76	24.00083333	0.254107
1928	18.91	25.8	26.9	21.81	24.02083333	-1.10814
1929	18.92	25.81	26.91	21.42	23.93083333	-0.61946
1930	18.93	25.82	26.92	21.71	24.01083333	0.337791
1931	18.94	25.83	26.93	21.97	24.08333333	-1.45936
1932	18.95	25.84	26.94	21.75	24.03583333	-0.7194
1933	18.96	25.85	26.95	21.77	24.04833333	0.536511
1934	18.97	25.86	26.96	21.55	24.00083333	-0.53529
1935	18.98	25.87	26.97	21.65	24.03333333	0.222408
1936	18.99	25.88	26.98	21.86	24.09333333	-0.11056
1937	19	25.89	26.99	21.14	23.92083333	-0.24673
1938	19.01	25.9	27	21.31	23.97083333	-0.03823
1939	19.02	25.91	27.01	21.67	24.06833333	0.242954
1940	19.03	25.92	27.02	21.91	24.13583333	0.315184
1941	19.04	25.93	27.03	22.3	24.24083333	-1.65991
1942	19.05	25.94	27.04	21.72	24.10333333	-0.4817
1943	19.06	25.95	27.05	21.68	24.10083333	0.713888
1944	19.07	25.96	27.06	21.76	24.12833333	0.409211

1945	19.08	25.97	27.07	21.16	23.98583333	0.275223
1946	19.09	25.98	27.08	22.13	24.23583333	-0.75416
1947	19.1	25.99	27.09	21.39	24.05833333	0.076262
1948	19.11	26	27.1	21.73	24.15083333	0.169363
1949	19.12	26.01	27.11	21.29	24.04833333	-0.13151
1950	19.13	26.02	27.12	21.14	24.01833333	1.300436
1951	19.14	26.03	27.13	22.45	24.35333333	0.550509
1952	19.15	26.04	27.14	21.77	24.19083333	-0.61285
1953	19.16	26.05	27.15	22.01	24.25833333	-1.26848
1954	19.17	26.06	27.16	21.15	24.05083333	-0.32808
1955	19.18	26.07	27.17	21.35	24.10833333	0.57711
1956	19.19	26.08	27.18	21.41	24.13083333	0.712994
1957	19.2	26.09	27.19	21.94	24.27083333	1.255041
1958	19.21	26.1	27.2	22.13	24.32583333	-1.19483
1959	19.22	26.11	27.21	22	24.30083333	0.003429
1960	19.23	26.12	27.22	21.84	24.26833333	-0.0892
1961	19.24	26.13	27.23	21.17	24.10833333	0.451389
1962	19.25	26.14	27.24	21.47	24.19083333	0.627427
1963	19.26	26.15	27.25	22.04	24.34083333	0.7902
1964	19.27	26.16	27.26	21.58	24.23333333	0.55325
1965	19.28	26.17	27.27	22.1	24.37083333	1.249827
1966	19.29	26.18	27.28	21.83	24.31083333	-0.20183
1967	19.3	26.19	27.29	21.68	24.28083333	0.708558
1968	19.31	26.2	27.3	21.69	24.29083333	1.465469
1969	19.32	26.21	27.31	22.2	24.42583333	-0.13968
1970	19.33	26.22	27.32	21.55	24.27083333	0.044655
1971	19.34	26.23	27.33	21.48	24.26083333	1.467308
1972	19.35	26.24	27.34	21.88	24.36833333	1.113416
1973	19.36	26.25	27.35	21.53	24.28833333	-0.49843
1974	19.37	26.26	27.36	21.38	24.25833333	1.076389
1975	19.38	26.27	27.37	21.3	24.24583333	2.130722
1976	19.39	26.28	27.38	22.25	24.49083333	1.748373
1977	19.4	26.29	27.39	22.3	24.51083333	0.660507
1978	19.41	26.3	27.4	22.22	24.49833333	1.065732
1979	19.42	26.31	27.41	22.59	24.59833333	0.115317
1980	19.43	26.32	27.42	22.17	24.50083333	-0.20027
1981	19.44	26.33	27.43	21.68	24.38583333	0.47727
1982	19.45	26.34	27.44	22.02	24.47833333	1.359558
1983	19.46	26.35	27.45	21.71	24.40833333	1.195412
1984	19.47	26.36	27.46	21.82	24.44333333	0.755702
1985	19.48	26.37	27.47	21.84	24.45583333	0.023858
1986	19.49	26.38	27.48	21.9	24.47833333	1.150138
1987	19.5	26.39	27.49	22.29	24.58333333	0.054267
1988	19.51	26.4	27.5	22	24.51833333	0.402675
1989	19.52	26.41	27.51	21.94	24.51083333	2.000971
1990	19.53	26.42	27.52	22.11	24.56083333	1.449126
1991	19.54	26.43	27.53	21.87	24.50833333	0.940417
1992	19.55	26.44	27.54	22.04	24.55833333	1.690821
1993	19.56	26.45	27.55	22.21	24.60833333	0.729977
1994	19.57	26.46	27.56	21.97	24.55583333	0.391796
1995	19.58	26.47	27.57	23.19	24.86833333	-1.66733
1996	19.59	26.48	27.58	21.76	24.51833333	-0.12899
1997	19.6	26.49	27.59	21.89	24.55833333	1.901798
1998	19.61	26.5	27.6	22.42	24.69833333	-0.24906
1999	19.62	26.51	27.61	22.29	24.67333333	0.013512
2000	19.63	26.52	27.62	22.68	24.77833333	0.724932
2001	19.64	26.53	27.63	22.52	24.74583333	0.064025
2002	19.65	26.54	27.64	22.58	24.76833333	-0.92667
2003	19.66	26.55	27.65	22.23	24.68833333	-0.1281
2004	19.67	26.56	27.66	22.24	24.69833333	-0.16842
2005	19.68	26.57	27.67	21.93	24.62833333	0.196637
2006	19.69	26.58	27.68	22.66	24.81833333	-0.96435
2007	19.7	26.59	27.69	22.32	24.74083333	-0.11775
2008	19.71	26.6	27.7	22.87	24.88583333	1.120818
2009	19.72	26.61	27.71	22.58	24.82083333	-1.1516
2010	19.73	26.62	27.72	22.6	24.83333333	-1.18053
2011	19.74	26.63	27.73	22.71	24.86833333	0.803945
2012	19.75	26.64	27.74	22.35	24.78583333	0.388146
2013	19.76	26.65	27.75	22.5	24.83083333	0.043648
2014	19.77	26.66	27.76	22.47	24.83083333	0.407737
2015	19.78	26.67	27.77	22.99	24.96833333	0.234176

V. RESULTS

It has been observed that the average error based on least square technique using linear equation, 0.049%. It gives the minimum error, so it can be used for the prediction of Temperatures of futuristic years. Based on the result the of linear equation the error has been furnished for the actual Annual average Temperature of the year 2016 and 2017 in table 3.

Table 3: Result on the tested data by Linear Equation

Year	Actual Temp.	Predicted Temp.	Error (%)
2016	26.45	26.46298	0.012984
2017	26.29	26.30291	0.012906

Table 4: Result on the tested data by Exponential Equation

Year	Actual Temp.	Predicted Temp.	Error (%)
2016	26.45	25.4	0.97
2017	26.29	26.85	0.59

Table 5: Result on the tested data by Curvilinear Equation

Year	Actual Temp.	Predicted Temp.	Error (%)
2016	26.45	26.38	0.92
2017	26.29	26.01	0.56

Table 6: Result on the tested data by Asymptotic Equation

Year	Actual Temp.	Predicted Temp.	Error (%)
2016	26.45	26.4	0.97
2017	26.29	26.85	0.59

Table 7: Result on the tested data by Logarithm Equation

Year	Actual Temp.	Predicted Temp.	Error (%)
2016	26.45	26.92	1.77
2017	26.29	26.92	2.39

So it has been observed that the predicted Annual Temperature for 2016 and 2017 are 26.46 and 26.30 degree Celsius respectively. Comparing with the actual Annual Temperature and we found very less Error i.e. 0.012% and 0.012% respectively.

VI. CONCLUSION

The said work has been undertaken on the available data from the year 1901 to 2017. Prediction has major impact on

Weather forecasting. If the said information is available in advance, necessary planning work can be decided prior. It will be helpful for the Governments along with the Citizens in the country. The estimated Annual average Temperature is 26.46 degree and 26.30 degree Celsius for the years 2016, 2017 respectively. Soft computing techniques will be used for the further minimization of the error.

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Authors Profile

Arindam Roy is currently pursuing his Post Graduate Degree in the field of Computer Science and Engineering From JIS College of Engineering, Kalyani, Nadia. He did his B.tech degree in Computer Science and Engineering from Maulana Abul Kalam Azad University of Technology, West Bengal (Formerly known as West Bengal University of Technology). He completed his Graduation in the year 2017 from JIS College of Engineering, Kalyani, Nadia. He has interest on Web Development and Designing. He has experience on Adobe Photoshop. He did a Training on Android on the year 2016-17.

Dharmpal Singh received his Bachelor of Computer Science and Engineering and Master of Computer Science and Engineering from West Bengal University of Technology. He has done his Ph.D in year 2015. He has about 12 years of experience in teaching and research. At present, he is with JIS College of Engineering, Kalyani, and West Bengal, India as an Associate Professor and Head of the department. He has published 32 papers in referred journal and conferences index by **Scopus, DBLP and Google Scholar and editorial team and senior membe**r of many reputed journal index by **SCI, Scopus, DBLP and Google Scholar**. He has organized **seven national levels Seminar/Workshop, published three patent** and has applied for the **AICTE Project in year of 2019.**

Sudipta Sahana is an assistant professor of a renowned engineering college of West Bengal. For more than 5 years, he has worked in this region. He has passed his M.Tech degree in Software Engineering and B.Tech Degree in Information Technology from West Bengal University of Technology with a great CGPA/DGPA on 2010 and 2012 respectively. He is recently working in Ph.D. in the domain of “Cloud Computing”. He is a member of the Computer Science Teachers Association (CSTA), and also a member of International Association of Computer Science and Information Technology (IACSIT).

Ira Nath has received her M.Tech degree in Software Engineering from the Maulana Abul Kalam Azad University of Technology, West Bengal, India (MAKAUT) in 2008 formerly West Bengal University of Technology (WBUT), India. She is currently pursuing her Ph.D in Computer Science & Technology at Indian Institute of Engineering Science and Technology (IIEST), Shibpur, India formerly Bengal Engineering and Science University (BESU)**,** Shibpur, India.. She is currently an assistant professor in the department of Computer Science & Engineering, JIS College of Engineering, Kalyani, Nadia. Her research interests include WDM optical Networks, Mobile Adhoc Network and network security. She is a life time member of CSI.

