A Study On the Local Weather Synthesis by The Adjusted Inverse Distance Weighted (AIDW) Interpolation

Md. Abdul Al Mohit and Md. Towhiduzzaman

Abstract — In this study, a modified spatial interpolation method called Adjusted Inverse Distance Weighted (AIDW) is used to analyze meteorological data around the Islamic University, Bangladesh. For the analysis of meteorological data, data were collected from different areas of Islamic University, Kushtia by the well-known portable weather meter Kestrel 3500 weather meter. For the synthesis of the observed data, an efficient solution to the problem of two-dimensional interpolation from irregularly-spaced data points in order to anticipate and calculate the desired value, a non-uniform distribution of sample points is used. This method of research is used on some important parameters related to weather and the weather of the study area. A reasonable agreement with the observed and synthesis data of Adjusted Inverse Distance Weighted (AIDW) interpolation was found in this study.

Keywords — Climate, Meteorology, Temperature, Weather.

I. INTRODUCTION

At present, the important thing is to extrapolate a continuous surface from point samples by means of special interpolation. A number of specialized spatial interpolation methods are used to transform point data into continuous surface maps and have been extensively researched by some authors [1]–[5]. AIDW is widely used in various research fields such as hybrid methods, geographic statistical research, environmental statistics, environmental data analysis, missing value imputation methods, and some relevant and non-relevant fields. Some well-known similar methods are spline and trend, surface polynomial regression, natural neighbor, radial basis function (RBF), and triangular irregular network (TIN) [5], [6] are classified. Sometimes, many types of interpolation are used in environment and weather research. For geographical statistics and weather parameter estimation, Kriging methods [7], [8] are widely used. However, some well-known hybrid interpolation methods are also widely used such as AIDW that used in our research. Also more notable are linear mixed models, regression kriging, and lapse rate combined with kriging [9]–[12]. In this study, we used modified IDW for environmental data analysis, especially for unknown point data analysis. A useful method such as inverse distance weighting (IDW) is a deterministic method for multivariate interpolation with a known data set of points. This method calculates the weighted average of the available values at the known points with the known values at the unknown points. Our modified IDW is what we call AIDW. This method implicitly assumes that objects are close to each other. The prediction uses measured values around a location. This method is used to predict a value at any unmeasured location. Measured values closest to the prediction location have a greater influence on the predicted value than distant locations. The major advantage of AIDW is keeping the measured value at the sample location [4], [13], [14]. AIDW has advantages over the use of IDW because clustering of sample points does not always work well when working with IDW [15], [16]. A further problem of IDW is contour plotting. Contour plotting of IDW interpolation [17] often results in a "bull's eye" pattern. Therefore, Hooyberghs and Golikhatmi [18], [19] introduced a new type of interpolation to improve the interpolation accuracy and that is the gradient plus Inverse Distance Square (GIDS) method. Some researchers [15] found that the p-value of IDW can be changed if an adaptive inverse-distance weight follows the sample point clustering pattern. However, the IDW methods published by various researchers attempt to extract the sample point information to approximate points by averaging the distance effects of different sample points. Therefore, the interpolating reasonableness of IDW is still in doubt, especially under the condition that the sample points are not uniformly distributed around the estimation point. This study was applied in the Islamic University, Bangladesh region for the meteorological data analysis and prediction, adjusted inverse distance weighted interpolation known as (AIDW) is used to simulate the meteorological data. The data

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Md. A. Al Mohit, Department of Mathematics, Islamic University, Bangladesh.
(e-mail: mohit4010@yahoo.com)
Md. Towhiduzzaman, Department of Electrical & Electronic Engineering (EEE), Uttara University (UU), Bangladesh.
(corresponding e-mail: towhid.math.iu@gmail.com)
parameters are Humidity, Temperature, Heat Stress and Air Pressure. In this study, the modified inverse
distance weighted interpolation is used to estimate the meteorological parametric data within the free region
of the University campus. The estimated result of this study is well with the observed data.

II. MATERIAL AND METHODS

A. Study Area

Islamic University, Bangladesh, commonly known as Islamic University, Kushtia abbreviated as IU, is
one of the premier public research and PhD-granting universities in Bangladesh and the largest university
with higher education seats in the southwestern part of the country. It has about 18000 + undergraduate and
postgraduate students. About 2300 students are admitted to this university every year. Its geographical
location is 23.7212N 89.1505E (Fig. 1). The weather temperature of Islamic University is such that it is
never too hot or too cold. The average temperature of our study area is 37 °C maximum and 11.2 °C
minimum. The real winter starts here in December when the days are sunny and the weather is dry.

Then, severe cold is experienced in January, with low temperatures around 5 °C-11 °C and highs around
23 °C-35 °C. The actual monsoon begins in the south-east in late May and early June. It also brings more
compact clouds, high humidity during the day. Frequent rains, but also a drop in temperature, which drops
to 30/32 °C during the day. Annual rainfall in Islamic University is about 1467 mm. The Longitude of
Islamic University is 89.150835 and the latitude is 23.726763N (see, Fig. 1). Also the pressure ranges
between 1015.2 hPa to 1015.6 hPa. Islamic University Garai River is about 23 km from Kushtia so its
humidity is about 79% and average wind speed is 13 km/h. A map view of our study area can illustrate the
domain area more easily.

B. Data

In this section, we will explain how we collected and analyzed climate and environmental data. Weather
or environmental data is collected based on environmental measurements. Data collection is a systematic
process of collecting observations or measurements. We are doing research for various purposes, but,
mainly, here we are doing research for academic purposes. Data collection helps us gain direct knowledge
and key insights about the research problem. For this we collect data of different parameters of weather
from different places of our campus (Islamic University, Bangladesh). First, we collect data on longitude,
latitude, pressure, heat stress index, and relative humidity at various points on campus. Here we collect this
information from the campus gate first and then from the different locations of Islamic University,
Bangladesh. The data collection locations of the university are Main gate, Auditorium, Saddam Hossain
Hall, Jatir Pta Bangabandhu Sheikh Mujibur Rahman Hall, Deshratno Sheikh Hasina Hall, Bangamata
Sheikh Fazilatunnesa Mujib Hall, Khaleda Zia Hall, IU Central Mosque, Lake, VC Residence, Dr. M. A.
Wazed Miah Science Building. In this whole process, we use a device called Kestrel 3500 to collect data.
The Kestrel 3500 Weather Meter is designed as a portable weather meter capable of measuring
environmental variables such as temperature, wind speed, barometric phenomena, pressure trends for up to
3 hours, and more rugged and affordable meters provide a full range of reliable weather measurements.
C. Mathematical Procedure

Every Interpolation aims at finding the values of a function \( f(x) \) for an \( x \) between different \( x \) values \( x_0, x_1, \ldots, x_n \) at which the values of \( f(x) \) are given. The given values can be obtained from a mathematical function or from an empirical function modeled from observations or experiments (1).

\[
f_0 = f(x_0), f_1 = f(x_1), \ldots, f_n = f(x_n)
\]  

(1)

Spatial interpolation therefore aims at estimating values of a spatial phenomenon or function (temperature, humidity, etc.) at unobserved/estimated points. The reason for using AIDW instead of IDW in this study is to add a coefficient (K) to the weights at those points to adjust the distance to the sample points. This new coefficient (K) has an important effect on the newly predicted values. This new coefficient (K) value protects against the influence of the weighting of points far from the predicted point. The modified adjusted IDW is (2).

\[
Z_{new} = \frac{\sum_{i=1}^{n} k_i Z_i (d_i)^p}{\sum_{i=1}^{n} k_i (d_i)^p}
\]  

(2)

Where the estimated value for prediction point is denoted as \( Z_{new} \), \( Z_i \) represents the measured value for sample point, \( d_i \) is the distance between two sample points and \( p \) is the power parameter. Whereas the \( k_i \) can be calculated form the modified rules as (3).

\[
k_i = \begin{cases} 
1; & i = 1 \\
\prod_{j=1}^{i-1} \sin^p \theta_{ij}; & i = 2, 3, 4, \ldots, n
\end{cases}
\]  

(3)

In this study, we have collected data from the different locations of Islamic University, Kushthia. The data was taken on 22nd August 2021 from 11.00 AM to 12.30 PM. Most of the data were collected inside the Islamic University boundary. At first, we used the Kestrel 3500 weather meter to collect the raw data on that day from the different locations inside the Islamic University campus. We have collected data from 12 different locations and for a better result, we have to calculate the desired value by another 7 points. In our study, we use the AIDW calculation process. First of all, we count all the observed points and target points. Then, we extract the weight and the distance. After that, we rearrange the distance and pick the lowest distance from the data set. For the modification, we set the nearest neighbor technique before applying the AIDW. We set the lowest distance plus half of the height distance. We continue the same process extending 10% of the half-of-height distance. When we found the 90% observed point is in the neighborhood to the lowest distance then we stop the calculation process.

III. RESULTS

In this study, we want to estimate weather data synthesis by using modified IDW known as AIDW. For this reason, we have collected weather data manually by the handy data collected equipment Kestrel 3,500 Weather Meter. Our actual research required information on several points. But we collect data at a small number of places on Earth and evaluate values at many places with the AIDW method. We see the data collection point for Fig. 2.

![Data Collection Point Map](image)

Fig. 2. Data collection point around the Islamic University campus.

After collecting the data, we apply the AIDW. Before that we selected the estimated data location points. In this study, we have considered four different weather parameters for the entire campus area to estimate
the contour profile. The four different parameters of weather are; Temperature, barometric pressure, humidity and heat index. Contour plots of each parameter are shown below. In this study we collect values of temperature, barometric pressure, humidity and heat index parameters using the Kestrel 3,500 weather meter. Then depending on the particular place values, we use AIWD to determine many more place values. Now we have one place observation data and our calculations to know if our AIWD is giving correct results or not. Then, we check our results and find that the observational data and the AIDW data match very well.

![Fig. 3. (a) Contour plot of Heat index and (b) the contour on google map.](image1)

![Fig. 4. (a) Contour plot of Humidity and (b) the contour on google map.](image2)

It can be seen from the above figure that the values of weather parameters have been determined at all places in the study area from a small amount of data. Then from the contour plot of the data we know the results for all the locations of the study area (see Fig. 3 (a) and Fig. 4. (a)).

![Fig. 5. (a) Contour plot of Pressure and (b) the contour on google map.](image3)
Next, we interpolate the data that we obtained from the simulation into the shape regions of our study and display them according to the Map. We use Google Earth Pro software for interpolation in specific shape regions.

IV. DISCUSSION

In this research, we use a new IDW to collect and analyze weather data, which is AIDW. By using this method, we interpolate the observation data at all locations in our study area. However, an observation is made to see how well the data obtained by this interpolation method matches our observational data. Consider the target point as an interpolation point. After that, we run the program created with MATLAB. Now we compare the values of the obtained data of the point and the point which we have targeted as the interpolation point. Table I shows the comparison of the interpolation value and the observed value for different weather parameters.

From the results, we can see that the data obtained by this new type of interpolation method show good agreement with our observational data. As we know, contour plot is an educational graphical technique that represents a 3-dimensional surface in a 2-dimensional format by creating constant z slices called contours. That is, given a value of z, lines are drawn to connect the (x, y) coordinates at which that z value occurs. So that, in our research, we try to present our obtained values nicely by contour plotting. But the major challenge of our work was masking our research area. Because the contour we created at first was square. After that, we create a contour map of the interpolation data at the study area based on the layout of Islamic universities.

From Table I, it is clear that the observed and calculated data coincide more with each other. So this work is compatible with weather data analysis. For the statistical analysis, the comparison result makes 93% in agreement with each other. Thus we recommend this work for the better analysis of weather data for sustainable development of Future environmental and weather analysis.

V. CONCLUSION

Though the IDW method is commonly used in spatial analysis, it has the shortcomings of neglecting sample points clustering and inclining to emerge isolated circles and concentric circles in its contour plotting. For the sake of overcoming the above problems, this study improved the IDW algorithm and put forward a new method called AIDW. AIDW decides whether or not to have shielding influences among sample points, and weighs the shielded contribution of the point shielded by other points using the coefficient (K). Theoretical analysis and the case study indicated that the AIDW method could acquire more reasonable interpolations than the IDW method. Moreover, the contour plotting of AIDW can effectively avoid the implausible isolated circles and concentric circles which often exist in IDW interpolation; its
contour plotting has more rationality and aesthetic. This AIDW can easily calculate data with 93% accuracy in the study area. So, this technique is more useful for the weather data synthesis.

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CONFLICT OF INTEREST

The authors declare no competing financial or personal interests that may appear and influence the work reported in this paper.

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