For office use only	Team Control Number	For office use only
T1 ________________	**33652**	F1 ________________
T2 ________________		F2 ________________
T3 ________________	Problem Chosen	F3 ________________
T4 ________________	**A**	F4 ________________

2016 Mathematical Contest in Modeling (MCM/ICM) Summary Sheet

Fresh Air Guardian—-Evaluation of Air Quality in Xi'an

Summary

After mathematically analyzing the question of evaluating the air conditon and making suggestion in Xi'an, our modeling group would like to present our conclusions, strategies, and recommendations.

About Problem I, many factors contribute to air pollution concentration levels. Factors like the weather, the landform of this area, chemical transformations in the air, and transport of pollutants from outside area all play a role. Considering all those factors, we establish the model of discrete wavelet transform, and analyse the time and spatial distribution of AQI. We draw a conclusion that the periodic variation of AQI changes is seasonal, winter and spring are the worst season in Xi'an, especially in December and January. Meanwhile, Central and Eastern Xi'an, air pollution is serious. The West and the surrounding areas of Xi'an, the air is better than the other areas.Through this model, we basically discover the trend of time and spatial distributuon of air condition in Xi'an.

As to Problem II, after calculating the air quality index of Xi'an, we analyse the data of air polutant composition and find the main factors influencing the air quality. As far as we are convinced that the emission, weather and the centra heating are the three main influences. At the same time, we also discover the progress how do these factors affect air quality.Finally,we verify our conclusions and explian the specific method we use.

The last problem is Problem III. We write a suggestion letter to the mayor of our city. The two questions' results above are the basis of our conclusion. After completing all the data analysis, we finally finish this letter, in which we present our advices to improve the condition of air quality in Xi'an area while have little excessive impact of economic development.

After testing a variety of real data, we believe that the model is reliable. Furthermore, by slightly adjusting the coefficients, we can apply this model into various evaluating field of environment condition.

Keywords: Discrete Wavelet Transform; Cluster Analysis; Dual Model Fusion; SPSS;

Contents

1 Introduction

1.1 Background

After 30 years of rapid development, Chinese economy has obtained gratifying achievements. People's living standards have gradually improved, meanwhile, the social consciousness has also been enhanced, the public affairs have attracted more and more attention.

In recent years, **the air quality** has become one of the most concerned topics. Because of the perishing air quality, peopel start to pursue causes of air pollution. Especially the effects of haze on human health has attracted more and more attention, the country is seeking effective measures to control the haze.

Air pollution is the introduction of particulates, biological molecules, or other harmful materials into Earth's atmosphere, causing diseases, death to humans, damage to other living organisms such as animals and food crops, or the natural or built environment. Air pollution may come from anthropogenic or natural sources.It has several causes as follows:

- Burning of Fossil Fuels

  Sulfur dioxide emitted from the combustion of fossil fuels like coal, petroleum and other factory combustibles is one the major cause of air pollution. Pollution emitting from vehicles including trucks, jeeps, cars, trains, airplanes cause immense amount of pollution.

- Agricultural activities

  Ammonia is a very common by product from agriculture related activities and is one of the most hazardous gases in the atmosphere.

- Exhaust from factories and industries

  Manufacturing industries release large amount of carbon monoxide, hydrocarbons, organic compounds, and chemicals into the air thereby depleting the quality of air.

- Mining operations

  Mining is a process wherein minerals below the earth are extracted using large equipments. During the process dust and chemicals are released in the air causing massive air pollution.

- Indoor air pollution

  Household cleaning products, painting supplies emit toxic chemicals in the air and cause air pollution.

Xi'an is a large inland city, and the economic locomotive of the northwest region. It is located in the Guanzhong Plain, and the environment is close. Because of its location, the air pollution of Xi'an is awful. Air quality has become urgent problems to solve. Our team builds sveral models to analyse it.

1.2 Problem Restatement and Analysis

According to the problem we ought to settle, we should collect some meteorological data and air quality data from some public data sites of Xi'an in recent years, and establishe models to complete the following works:

Problem I Many factors contribute to air pollution concentration levels. Emission levels are not the only factor that determines concentrations of air pollutants. Factors like the weather, the landform of this area, chemical transformations in the air, and transport of pollutants from outside area all play a role. This means that a reduction in emissions of a pollutant do not always translate to an equivalent reduction in concentrations of that pollutant. According to the given question, we are required to build a comprehensive, and well time-applicability model, which includes establishing reasonable evaluation index relies on different space and time fields and evaluating the trend of the air quality in Xi'an.

Problem II After calculating the air quality index of Xi'an, we need to analyse the data of air polutant composition and find the main factors influencing the air quality. At the same time, we also ought to discover the progress how do these factors affect air quality.Finally,we should verify our conclusions and explian the specific method we use.

Problem III The two questions' results above are the basis of our conclusion. After completing all the data analysis, we are required to write a **letter** to the relevant government departments, presenting the **suggestion** which can improve the condition of air quality in Xi'an area while have little excessive impact of economic development.

Having considered about all the requirements above, our goal is to construct a comprehensive evaluation model to analyse the air quality of Xi'an, meanwhile, gain further analysis and answers for the problem.

2 Assumption

(1) Assuming that the direct acting factors of air condition are SO_2, NO_2, PM_10, CO, 0_3, and $PM_2.5$.

(2) Assuming that the data we have chosen is true and reliable.

(3) The evaluation of air quality and its influencing factors among different regions can be concluded through the data of 2011-2013, we assumpte that those influencing factors are not changed with time.

(4) Assuming that the pollution of the gas does not affect each other.

(5) Assuming that each region does not affect each other.

3 Symbol Description

In the section, we use some symbols for constructing the model as follows.

Symbol	Description
$IAQI_P$	Air quality index of pollutant item
BP_{Hi}	High value of pollutant concentration limit withï¡đCP in table(1)
BP_{Lo}	Low value of pollutant concentration limit withï¡đCP in table(1)
$IAQI_{Hi}$	Air quality index corresponding to BP_{Hi} in table(1)
$IAQI_{Lo}$	Air quality index corresponding to BP_{Lo} in table(1)
$IAQI$	Air quality index
n	Pollutant Items
$\psi(t)$	Mother Wavelet
γ	Wavelet Coefficient
$x(t)$	signal

P.S:Other symbol instructions will be given in the paper.

4 Model Preparation

4.1 Technical Regulation on Ambient Air Quality Index (on trial)[3]

In order to measure the level of air quality in Xi'an, we need to introduce some indices. These indices are defined in accordance with national standards defined by ***Ministry of environmental protection of the people's Republic of China*** as follows.

4.1.1 Basic Nomenclature and Definitions

- Air Quality Index(AQI)

  Non dimensional index of air quality quantitative description.

- Individual Air Quality Index(IAQI)

  Air quality index of single pollutant.

- Primary Pollutant

  IAQI maximum air pollutants when AQI is greater than 50.

4.1.2 Air Quality Index Calculation Method

(1) Air quality index classification scheme

Air quality index levels and the corresponding pollutant concentration limits is shown in Table 1.

Table 1: Air Quality Index and the Corresponding Pollutant Concentration Limits

Individual Air Quality Index(IAQI)	SO_2 24-hour average $\mu g/m^3$	NO_2 24-hour average $\mu g/m^3$	PM_{10} 24-hour average $\mu g/m^3$	CO 24-hour average $\mu g/m^3$	O_3 8-hour average $\mu g/m^3$	$PM_{2.5}$ 24-hour average $\mu g/m^3$
0	0	0	0	0	0	0
50	50	40	50	2	100	35
100	150	80	150	4	160	75
150	475	180	250	14	215	115
200	800	280	350	24	265	150
300	1 600	565	420	36	800	250
400	2 100	750	500	48	(1)	350
500	2 620	940	600	60	(1)	500
P.S	(1) If 8-hours average concentration of ozone is higher than $800 g/m^3$, then the calculation of air quality index is no longer include ozone.					

(2) Air Quality Index Calculation Method

Air quality index of pollutant item P is calculated according to equation(1):

$$IAQI_P = \frac{IAQI_{Hi} - IAQI_{Lo}}{BP_{Hi} - BP_{Lo}}(C_P - BP_{Lo}) + IAQI_{Lo} \tag{1}$$

Where:

- $IAQI_P$—-Air quality index of pollutant item
- BP_{Hi}—-High value of pollutant concentration limit withï¡đCP in table(1)
- BP_{Lo}—-Low value of pollutant concentration limit withï¡đCP in table(1)
- $IAQI_{Hi}$—-Air quality index corresponding to BP_{Hi} in table(1)
- $IAQI_{Lo}$—-Air quality index corresponding to BP_{Lo} in table(1)

4.1.3 Air Quality Index and Method for Determination of Primary Pollutant

(1) Air Quality Index Calculation Method

Air quality index is calculating according to equation(2):

$$AQI = max\{IAQI_1, IAQI_2, IAQI_3, ..., IAQI_n\} \tag{2}$$

Where:

- $IAQI$—-Air quality index
- n—-Pollutant items

(2) Method for Determination of Primary Pollutant

When AQI is greater than 50, the biggest pollutant of $IAQI$ is the primary pollutant. If the largest pollutant of $IAQI$ are two or more than two items, we set all of them as the primary pollutant.

4.2 Data Capture

In order to establish a reasonable evaluation index and make a reasonable assessment of the air quality changing trend in recent years, aiming at different time and spatial domain in Xi'an. We need to refer to some vital data from reasonable websites.

After searching data through surfing the Internet, we find that the ***Xi'an environmental monitoring station*** [4] has authoritative data. In their website, we can not only obtain the historical data from 2010 to 2015, but also the independent data of each monitoring station distributed in Xi'an City. The following figure(1) is the screenshot of the website.

>>空气日报 质量 点位名称: 首要污染物: 发布时间: 检索

序号	点位名称	SO_2	NO_2	PM_{10}	CO	$O_3$1小时	$O_3$8小时	$PM_{2.5}$	首要污染物	发布时间
61	高压开关厂	40	97	141	40	-	6	198	中度	2015-12-28
62	兴庆小区	40	105	193	93	-	9	189	中度	2015-12-28
63	纺织城	39	78	187	69	-	7	NA	中度	2015-12-28
64	小寨	53	100	176	73	-	6	202	重度	2015-12-28
65	市人民体育场	20	43	173	80	-	8	216	重度	2015-12-28
66	高新西区	60	101	195	79	-	6	212	重度	2015-12-28
67	经开区	52	104	180	92	-	7	201	重度	2015-12-28
68	长安区	42	89	181	85	-	8	212	重度	2015-12-28
69	阎良区	21	78	110	105	-	17	153	中度	2015-12-28
70	临潼区	NA	NA	NA	NA	-	NA	NA	NA	2015-12-28
71	曲江文化集团	NA	NA	NA	NA	-	NA	NA	NA	2015-12-28
72	广运潭	38	52	180	107	-	11	228	重度	2015-12-28
73	草滩	39	38	159	106	-	15	128	中度	2015-12-28
74	全市平均	42	85	172	87	-	9	203	重度	2015-12-28
75	预报指数					230-250			PM2.5	2015-12-29

Figure 1: Air Quality Historical Data of Xi'an Partly(2010-2015)

Obviously, we can not manually download such a huge data. Therefore, our team write a ***web crawler*** program using ***Python*** to automatically obtain all the historical data of the website.The following table(2) is the partly result of the web crawler fetching.

5 Problem I

5.1 Time Analysis Model Based on Discrete Wavelet Transform

In numerical analysis and functional analysis, a discrete wavelet transform (DWT) is any wavelet transform for which the wavelets are discretely sampled. As with other wavelet transforms, a key advantage it has over Fourier transforms is temporal resolution: it captures both frequency and location information (location in time).

By coincidence, in the temporal variation analysis of air quality, the data we have obtained

Table 2: Data Acquired by Web Crawler

No.	Location	SO2	NO2	PM10	CO	O3	PM2.5	Time
1	High Voltage Switch Factory	59	112	115	27	18	137	2016-1-1
2	Xingqing Garden	61	121	140	94	14	139	2016-1-1
3	Textile City	44	72	132	75	19	220	2016-1-1
4	Xiaozhai	53	108	126	84	14	129	2016-1-1
5	Gym	27	57	148	91	14	196	2016-1-1
6	High-tech Development West Zone	59	101	165	92	21	190	2016-1-1
7	Economic Development Zone	54	120	185	103	20	212	2016-1-1
8	Changan	52	105	119	101	26	127	2016-1-1
9	Yanliang	NA	NA	NA	NA	NA	NA	2016-1-1
10	Lintong	57	79	142	91	17	166	2016-1-1
11	Qujiang	15	55	168	30	7	NA	2016-1-1
12	Guangyuntan	56	58	168	113	14	227	2016-1-1
13	Caotan	72	63	181	116	31	172	2016-1-1

is discrete, so we will use the method based on discrete wavelet transform to discover the trend of AQI.

One level of the transform

The DWT of a signal x is calculated by passing it through a series of filters. First the samples are passed through a low pass filter with impulse response g resulting in a convolution of the two:

$$y[n] = (x \times g)[n] = \sum_{k=-\infty}^{\infty} x[k]g[n-k] \tag{3}$$

The signal is also decomposed simultaneously using a high-pass filter h . The outputs giving the detail coefficients (from the high-pass filter) and approximation coefficients (from the low-pass). It is important that the two filters are related to each other and they are known as a quadrature mirror filter.

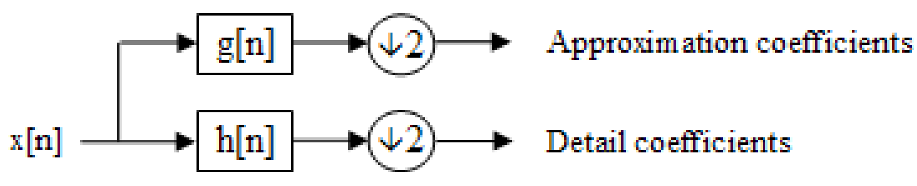

Figure 2: Block diagram of filter analysis

However, since half the frequencies of the signal have now been removed, half the samples can be discarded according to NyquistâĂŸs rule. The filter outputs are then subsampled by 2. In the next two formulas, the notation is the opposite: g- denotes high pass and h- low pass as is Mallat's and the common notation:

$$y_{\text{low}}[n] = \sum_{k=-\infty}^{\infty} x[k]h[2n-k] \tag{4}$$

$$y_{\text{high}}[n] = \sum_{k=-\infty}^{\infty} x[k]g[2n-k] \tag{5}$$

This decomposition has halved the time resolution since only half of each filter output characterises the signal. However, each output has half the frequency band of the input so the frequency resolution has been doubled.

With the subsampling operator $\downarrow$

$$(y \downarrow k)[n] = y[kn] \tag{6}$$

the above summation can be written more concisely.

$$y_{\text{low}} = (x \times g) \downarrow 2 \tag{7}$$

$$y_{\text{high}} = (x \times h) \downarrow 2 \tag{8}$$

However computing a complete convolution $x \times g$ with subsequent downsampling would waste computation time.

The Lifting scheme is an optimization where these two computations are interleaved.

Cascading and Filter banks

This decomposition is repeated to further increase the frequency resolution and the approximation coefficients decomposed with high and low pass filters and then down-sampled. This is represented as a binary tree with nodes representing a sub-space with a different time-frequency localisation. The tree is known as a filter bank.

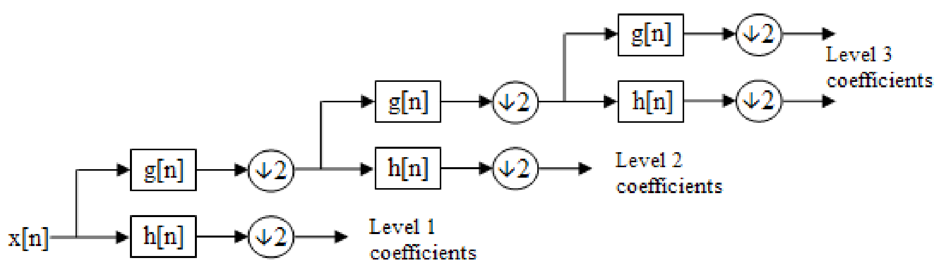

Figure 3: A 3 level filter bank

At each level in the above diagram the signal is decomposed into low and high frequencies. Due to the decomposition process the input signal must be a multiple of 2^n where n is the number of levels.

Relationship to the Mother Wavelet

The filterbank implementation of wavelets can be interpreted as computing the wavelet coefficients of a discrete set of child wavelets for a given mother wavelet $\psi(t)$. In the case of the discrete wavelet transform, the mother wavelet is shifted and scaled by powers of two

$$\psi_{j,k}(t) = \frac{1}{\sqrt{2^j}}\psi\left(\frac{t-k2^j}{2^j}\right) \tag{9}$$

where j is the scale parameter and k is the shift parameter, both which are integers.

Recall that the wavelet coefficient γ of a signal $x(t)$ is the projection of $x(t)$ onto a wavelet, and let $x(t)$ be a signal of length 2^N. In the case of a child wavelet in the discrete family above,

$$\gamma_{jk} = \int_{-\infty}^{\infty} x(t)\frac{1}{\sqrt{2^j}}\psi\left(\frac{t-k2^j}{2^j}\right)dt \tag{10}$$

Now fix j at a particular scale, so that γ_{jk} is a function of k only. In light of the above equation, γ_{jk} can be viewed as a convolution of $x(t)$ with a dilated, reflected, and normalized version of the mother wavelet, $h(t) = \frac{1}{\sqrt{2^j}}\psi\left(\frac{-t}{2^j}\right)$, sampled at the points $1, 2^j, 2^{2j}, ..., 2^N$. But this is precisely what the detail coefficients give at level j of the discrete wavelet transform. Therefore, for an appropriate choice of $h[n]$ and $g[n]$, the detail coefficients of the filter bank correspond exactly to a wavelet coefficient of a discrete set of child wavelets for a given mother wavelet $\psi(t)$.

In this problem, we use ***daubechies(dbN)*** function (N takes 6) as the mother wavelet, and decompose 4 layers. Finally, get the following results:

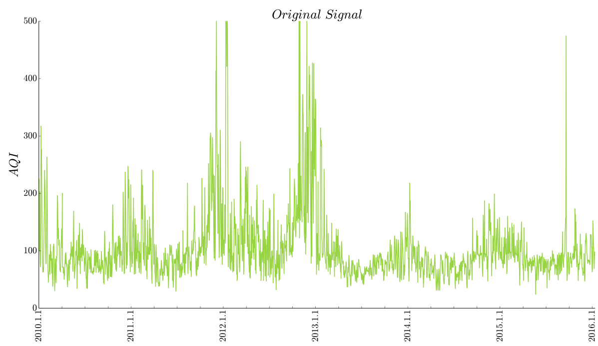

Figure 4: the Original Data of AQI(2010-2015)

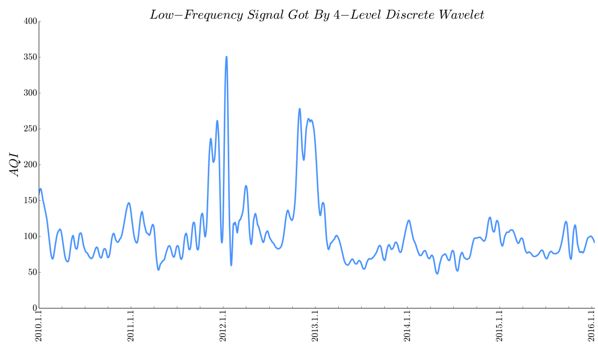

Figure 5: Low-frequency Signal got by 4-level Discrete Wavelet

The figure(4) is the original data.After processing the data by 4-level $db6$ function, the result is shown in figure(5).We can observe the change trend of the smooth curve approximately.

In order to be able to clearly predict the trend of air quality, we have reprocessed the data, and redraw the figure.Taking advantage of ***Python***, we divide the curve into 4 distinct time parts, and each part has a different color representing different season.

From the figure(6), we can see. the periodic variation of AQI is very obvious. AQI index is on the crest in spring (marked in green) and winter (marked in blue), significantly higher than in summer (marked in yellow) and autumn (marked in purple). From this figure, we can make a reasonable guess, the periodic variation of AQI changes is seasonal. Winter and spring are the worst season in Xi'an, especially in December and January.

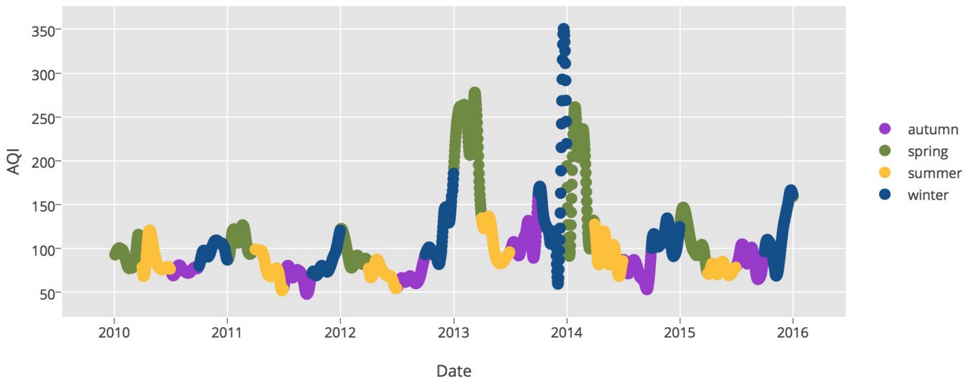

Figure 6: the Figure afer Tranforming

5.2 Spatial Analysis Model Based on Discrete Wavelet Transform

Using the above method, we analyze the spatial distribution of AQI.The figure(7) is the result we obtain. In order to let the result visualization, we use the ***Python*** to draw a 3-D map as follows.

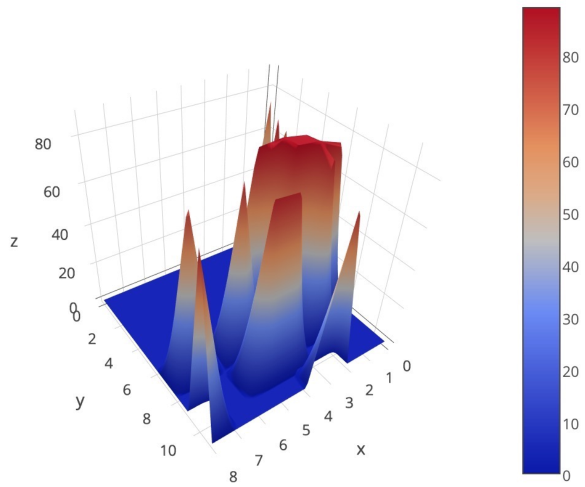

Figure 7: the Territorial Classification

In the figure(7), the X axis represents the east and west direction, the Y asis represents the north and south direction, the Z axis represents the air pollution index.

From the figure, we can see, in the Central and Eastern Xi'an, air pollution is serious, the AQI is very high. The West and the surrounding areas of Xi'an, the air is better than the other areas, the index is low. The most polluted areas are Economic Development Area and the High Voltage Switch Factory. The lightest polluted area is Bayuntan. Overall air pollution in various regions of Xi'an city is slightly different.

6 Problem II

Through the analysis of the problem I, we have obtained the variation trend of AQI with time and space. Referring to related knowledge and documentation, we come to the conclusion that the main factors mainly include two categories:emission of pollution sources and the weather.

6.1 Emission of pollution

An emission factor is a representative value that relates the quantity of a pollutant released to the atmosphere with an activity associated with the release of that pollutant. These factors are usually expressed as the weight of pollutant divided by a unit weight, volume, distance, or duration of the activity emitting the pollutant. Such factors facilitate estimation of emissions from various sources of air pollution. In most cases, these factors are simply averages of all available data of acceptable quality, and are generally assumed to be representative of long-term averages for all facilities in the source category. The emission factor is used to calculate the total emission from a source as an input for the emission inventory.

Cluster Analysis Model of Emission Factor

The difference of pollution source emission is mainly from space. We have to analyse the pollution sources in different regions and make comparison. As the observation point is too much to analyse, therefore, we use the method of cluster analysis to process the data, dividing them into 5 classifications.

Definition

Cluster analysis or clustering is the task of grouping a set of objects in such a way that objects in the same group (called a cluster) are more similar (in some sense or another) to each other than to those in other groups (clusters). It is a main task of exploratory data mining, and a common technique for statistical data analysis, used in many fields, including machine learning, pattern recognition, image analysis, information retrieval, and bioinformatics.

Cluster Analysis Process

Above is the basic definition of the clustering method, the following is the specific process of data clustering.

(1) Selecting clustering method. In this paper, we use the Ward method which is integrated in SPSS [5] software, and use ***Eucidean Distance*** to measure distance.

(2) Calculate the distance between n samples, and obtain the distance matrix $D^(0)$.

(3) At first, n samples constitute n classes by themselves(the first step:$i = 1$), and the i^th class is $G_i = X_{(i)}$ $(i = 1, 2, 3, ..., n)$. At this time, the distance between classes is the distance between samples ($D^{(1)} = D^W$). And then perform the next 4^th and 5^th step of the sample.

(4) The next step is amalgamating the two classes with the smallest distance into a new class. The total number of classes at this time is reduced 1 class, $k = n - i + 1$.

(5) Calculate the distance between the new class and the other classes, and get a new distance matrix $D^{(1)}$. If the total number k of the merged class is more than 1, repeat steps 4 and 5 until the number of classes is 1, and then go to step 6.

(6) Draw the diagram of pedigree clustering, and decide the number of class and the members the of each class.

The figure above is shown the variation trend of AQI after cluster analysis.

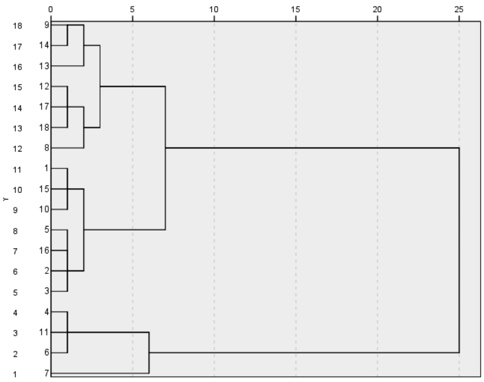

Figure 8: the Territorial Classification

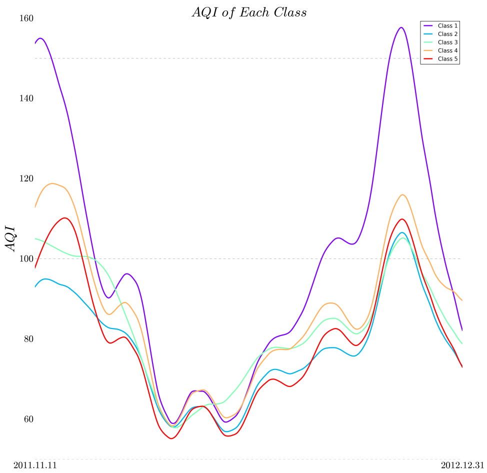

Figure 9: AQI of Each Class

Table 3: Classes of Regions in Xi'an

1	2	3	4	5
Factory Xingqing Textile hightech economicdevelopment Gym Xiaozhai	Ganting languan Bayunta	Caotan	Doumen Lintong Yanliang Changan	Guangyuntan luxiang Qujiang

6.2 Weather

To analyze the influence factors of air condition, we have to consider the impact of climate on it. There have lots of impact factors included in climate. After analysing(compare each curve of the factors with mothly AQI), we fully convince that the following three factors are the vitalest.

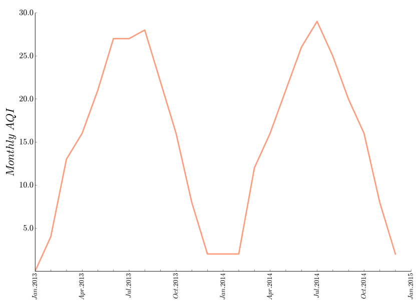

Figure 10: AQI Monthly(2013-2014)

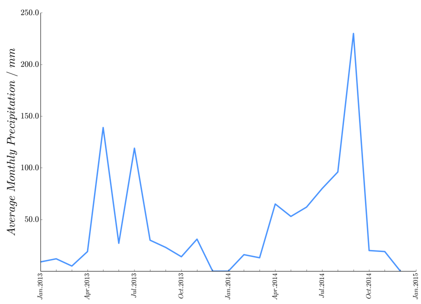

Figure 11: Average Precipitation Monthly(2013-2014)

- Average Precipitation

  Precipitation and AQI show a negative correlation trend. The more rain, the better air quality.

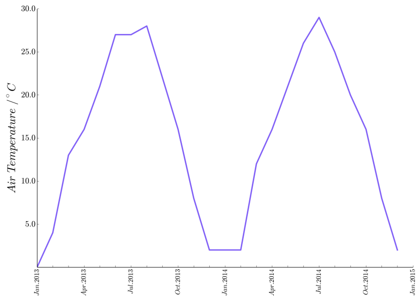

Figure 12: Average Temperature Monthly(2013-2014)

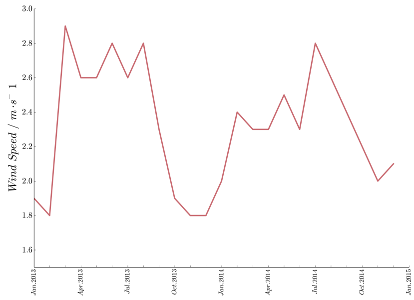

Figure 13: Average Wind Speed(2013-2014)

- Average Temperature

  Temperature and AQI show a negative correlation trend. The higher temperature is high, the better air quality.

- Average Wind Speed

  Wind Speed and AQI show a negative correlation trend. The larger the wind, the better air quality.

6.3 Central Heating

Fossil-fuel combustion related winter heating has become a major air quality and public health concern in Xi'an recently. We analyzed the impact of winter heating on air quality index, the result is obviously that the central heating would make striking rise on AQI. The figure as follows.

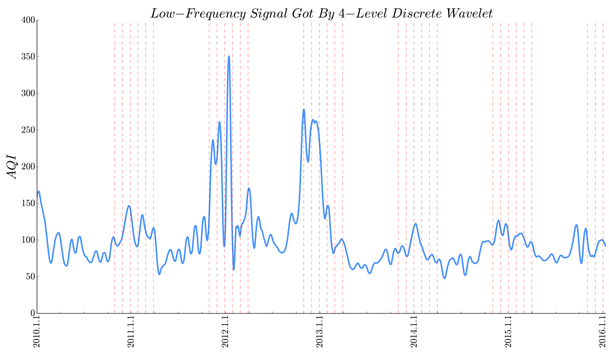

Figure 14: the Impact of Central Heating

The area marked in figure using black lines represent the center hearting period. From the figure above, our findings suggest that adopting pollution control facilities in power plants and heating stations are needed to improve winter air quality in Xi'an. Furthermore, developing heating systems supplied by renewable energy may be another sustainable solution for air quality improvement.

7 Strengths and Weaknesses

7.1 Strengths

Our model effectively achieves all of the goals we set initially. It is fast and can handle large quantities data of air quality, but also have the flexibility we desired.Though we did not test all kinds of impact factors, we showed that our model optimizes state districts for any of a number of variables.Our model can evaluate all kinds of AQI data from past to the present, it has wide range of application and good time applicability.As well, our method is robust.

7.2 Weaknesses

Weakness of the model included assumptions made for simplicity that likely do not hold. And some special data can't be found, such as the data of gross industrial production. And it makes that we have to do some proper assumption before the solution of our models. A more abundant data resource can guarantee a better result in our models.

8 Smog Suggestion Letter in Xi'an

Long for Blue Sky —- a letter from Fresh Air Guardian team to mayor

Dear Mayor,

Getting a breath of fresh air isn't as easy as it used to be. We've loaded the atmosphere with all kinds of pollutants that have triggered a number of serious atmospheric ills. The atmosphere is, in effect, talking back. It's warning us that it can't sustain more of our abuse without causing harm.

Pollution is the one of the biggest problem affecting the people in Xi'an. Even though the government has established strict law to control this issue, air pollution is still inevitable to some extent. However, some of the facts that why does the air pollution is so hazardous still not be discoverd.Our team has referred to some data, and make our conclusion as follows.

There are many kinds of pollution. Air, soil, water and sound pollution are some. Meanwhile, for aie pollution, it is made up of many sources of pollution, such as NO_2, SO_2, CO and so on. It is difficult to say which one is more risky than the other because all of them are dangerous and equally damage people's health.

Through analysing the air condition in Xi'an by our team, according to the pie chart below, we find that the central heating, vehicles, and the factories are the main influencing factors, which accounted for 89.6%.

According to the finding above, we would like to suggest some measures for controlling the growing air pollution in our city.

First of all, all heavy vehicles (HCVs) should be banned from entering the city and only light commercial vehicles, such as tempos should carry the goods to the heart of the city. The transport buses plying within the city should be replaced by electric vans and trolleys to ferry commuters within the city.

Secondly, all factories should be shifted to far-flung areas of the city. These steps along with the working of the complete Metro system will help in controlling the growing air pollution in

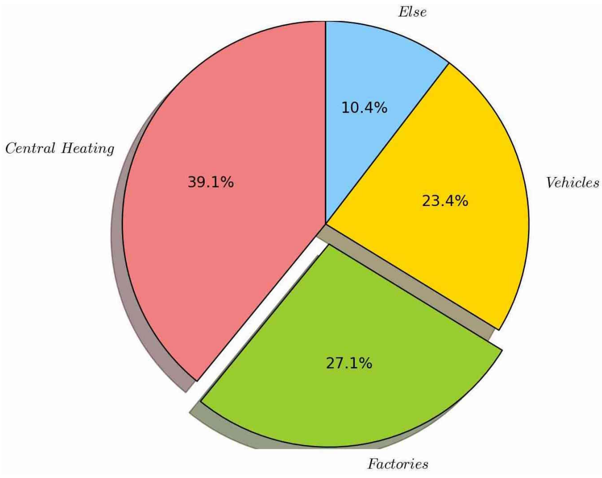

Figure 15: The Influence of Different Factors on Air Pollution

the city. Unless such and other similar steps are taken immediately, the problem of air pollution will certainly assume serious proportions.

The last but not the least, our government ought to consider forward-looking regulations to allow for carpooling and ride-sharing in the city. This will help de-congest roads, improve commute times, and take cars off the road. This would be achieved by Uber or Didi Dache. Meanwhile, encourage using the green energy. Green energy that produces no greenhouse gas emissions from fossil fuels and reduces some types of air pollution.

Our government should follow people's wishes to control air pollution even at the cost of less GDP and revenue. This may not make your term achievements dazzling, but what's more important than citizens' health and safety?

I hope the concerned authorities will pay prompt attention to this growing menace and initiate action.

Yours truly,
Fresh Air Guardian team

References

[1] D. E. KNUTH The TEXbook the American Mathematical Society and Addison-Wesley Publishing Company , 1984-1986.

[2] Lamport , Leslie , LATEX: " A Document Preparation System " , Addison-Wesley Publishing Company , 1986.

[3] Ministry of environmental protection of the people's Republic of China, Technical Regulation on Ambient Air Quality Index (on trial). http://kjs.mep.gov.cn/hjbhbz/bzwb/dqhjbh/jcgfffbz/201203/t20120302_224166.htm. 2012

[4] Xi'an environmental monitoring station, Air quality historical data. http://www.xianemc.gov.cn/sxmpcp_qt.asp?lb=%D6%CA%C1%BF%C8%D5%B1%A8. 2015

[5] SPSS China, Homepage. http://www.spss.com.cn/. 2016

[6] Pope CA, Dockery DW (2006) Health effects of fine particulate air pollution: Lines that connect. Journal of the Air & Waste Management Association. pp. 709-742.

[7] Cao JJ, Lee SC, Chow JC, Watson JG, Ho KF,et al. (2007) Spatial and seasonal distributions of carbonaceous aerosols over China. Journal of Geophysical Research-Atmospheres.

[8] Zhao PS, Dong F, He D, Zhao XJ, Zhang XL, et al. (2013) Characteristics of concentrations and chemical compositions for PM2.5 in the region of Beijing, Tianjin, and Hebei,China. Atmospheric Chemistry and Physics 13: 4631-4644. doi:10.5194/acp-13-4631-2013

[9] Anonymous (2011) China Electric Power Yearbook China: China Electric Power Press. doi: 10.1080/17437199.2011.587961. pmid:25473706

[10] Song Y, Zhang Y, Xie S, Zeng L, Zheng M, et al. (2006) Source apportionment of PM2.5 in Beijing by positive matrix factorization. Atmospheric Environment 40: 1526-1537. doi: 10.1016/j.atmosenv.2005.10.039

Appendices

Appendix A First appendix

Original Data

Time	$SO_2(mg/m^3)$	$NO_2(mg/m^3)$	$PM_10(mg/m^3)$	$CO(mg/m^3)$	$O_3(8/h\,ug/m^3)$	$PM_2.5(ug/m^3)$
Jan-13	0.118	0.08	0.298	3.628	40	206
Feb-13	0.079	0.061	0.263	3.641	54	203
Mar-13	0.055	0.072	0.345	2.942	68	122
Apr-13	0.031	0.061	0.19	2.2	81	82
May-13	0.021	0.048	0.122	1.3	86	57
Jun-13	0.017	0.036	0.09	1.342	95	42
Jul-13	0.015	0.036	0.094	1.4	103	52
Aug-13	0.021	0.039	0.115	1.1	116	59
Sep-13	0.029	0.053	0.136	1.563	93	79
Oct-13	0.036	0.07	0.199	2	69	116
Nov-13	0.048	0.054	0.139	1.8	27	66
Dec-13	0.085	0.076	0.287	3.2	26	182
Jan-14	0.093	0.079	0.247	2.9	29	146
Feb-14	0.066	0.056	0.24	2.4	34	171
Mar-14	0.036	0.051	0.19	2.2	52	84
Apr-14	0.016	0.044	0.149	1.7	66	63
May-14	0.015	0.032	0.144	1.5	80	55
Jun-14	0.013	0.034	0.096	1.4	108	46
Jul-14	0.011	0.035	0.086	1	130	35
Aug-14	0.012	0.041	0.093	1.2	106	44
Sep-14	0.011	0.041	0.075	1.3	66	40
Oct-14	0.021	0.051	0.15	1.5	54	78
Nov-14	0.039	0.051	0.151	1.9	29	84
Dec-14	0.055	0.051	0.148	2	27	67

Appendix B Second appendix

Processed Data

Time	Location	SO2	NO2	PM10	CO	O3	PM2.5	AQI
2016-1-1	High Voltage Switch Factory	59	112	115	27	18	137	137
2015-12-31	High Voltage Switch Factory	58	114	159	65	42	180	180
2015-12-30	High Voltage Switch Factory	39	50	97	45	33	102	102
2015-12-29	High Voltage Switch Factory	46	114	138	68	19	175	175
2015-12-28	High Voltage Switch Factory	40	97	141	40	6	198	198
2015-12-27	High Voltage Switch Factory	48	85	100	35	17	145	145
2015-12-26	High Voltage Switch Factory	47	68	74	36	22	87	87
2015-12-25	High Voltage Switch Factory	42	68	70	36	19	74	74
2015-12-24	High Voltage Switch Factory	34	62	111	29	26	124	124
2015-12-23	High Voltage Switch Factory	68	108	216	60	6	272	272
2015-12-22	High Voltage Switch Factory	59	101	128	49	8	193	193
2015-12-21	High Voltage Switch Factory	54	104	153	70	6	217	217
2015-12-20	High Voltage Switch Factory	48	104	146	56	8	203	203
2015-12-19	High Voltage Switch Factory	53	80	116	37	11	155	155
2015-12-18	High Voltage Switch Factory	29	65	86	25	18	98	98
2015-12-17	High Voltage Switch Factory	22	73	81	31	19	80	81
2015-12-16	High Voltage Switch Factory	12	73	61	24	28	38	73
2015-12-15	High Voltage Switch Factory	15	74	82	26	26	80	82
2015-12-14	High Voltage Switch Factory	19	98	75	39	14	77	98
2015-12-13	High Voltage Switch Factory	16	35	65	49	13	65	65
2015-12-12	High Voltage Switch Factory	22	22	90	50	16	105	105
2015-12-11	High Voltage Switch Factory	34	17	113	50	21	137	137
2015-12-10	High Voltage Switch Factory	29	29	115	50	8	118	118
2015-12-9	High Voltage Switch Factory	51	40	155	53	6	158	158
2015-12-8	High Voltage Switch Factory	39	45	145	50	6	155	155
2015-12-7	High Voltage Switch Factory	51	101	154	56	10	158	158
2015-12-6	High Voltage Switch Factory	60	93	149	50	8	150	150
2015-12-5	High Voltage Switch Factory	60	110	120	50	9	105	120
2015-12-4	High Voltage Switch Factory	45	102	81	49	22	59	102
2015-12-3	High Voltage Switch Factory	31	90	80	45	22	49	90
2015-12-2	High Voltage Switch Factory	23	68	116	43	26	50	116
2015-12-1	High Voltage Switch Factory	34	110	157	56	12	165	165
2015-11-30	High Voltage Switch Factory	37	124	365	71	6	325	365
2015-11-29	High Voltage Switch Factory	40	110	223	62	11	266	266
2015-11-28	High Voltage Switch Factory	40	106	181	58	7	208	208
2015-11-27	High Voltage Switch Factory	45	98	106	42	18	82	106
2015-11-26	High Voltage Switch Factory	32	82	58	36	16	32	82
2015-11-25	High Voltage Switch Factory	17	68	55	37	24	35	68
2015-11-24	High Voltage Switch Factory	5	69	34	39	12	23	69
2015-11-23	High Voltage Switch Factory	11	65	42	39	6	30	65