Predicting Human Locations with Big Five Personality and Neural Network

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***Abstract*—It is generally believed that human mobility pattern is affected by human personality. It implies human personality can influence future human location or usual frequent places. In such a manner, Big Five Personality Traits is utilized in order to figure out the effect of human personality toward human mobility model. The Back Propagation Network is used as a tool for identifying the effect of human personality to human mobility model. Human personality and preferred locations were related in a range of common sense. An algorithm is designed to simulate the effect of personality on human locations and represent the effect numerically. Our result will show the combinatorial effect of human personality and human mobility.**

***Index Terms*—Human mobility, probabilistic location prediction, big five factors, back propagation network, psychological factor, big five inventory, human mobility modeling, big five personality traits.**

I. Introduction

Human locations have been great interest of various related fields and it is now possible for researchers to collect human location information due to portable positioning devices and smartphones, and by help of big-data technology and data mining technology [1]. Once human locations can be predictable, so many related application areas such as advertisement, civil engineering, city or building planning and military will utilize such information [2].

Among many parameters for human location prediction, e.g. time, personality, personal income, age or so, we focused on human personality. In our previous research, we introduced a methodology in order to establish human mobility models with time attribute [3]. In this research, we are going to develop a process to predict human locations with the affluence of human personality.

It is clear that human mobility pattern is affected by human personality and thus researched already [4]. For example, persons with extraversion may prefer outdoor activity to persons with introversion [2].

Among many personality models, we will introduce big five personality traits which are a commonly acceptable model for human personality [5], [6]. As well back propagation network (BPN) will be used as a tool for combine human mobility and human personality.

In Section II, we will show brief introduction of big five personality and BPN. Section III will discuss a detailed method for human location prediction. An algorithm will be introduced as well as input parameters. The input parameters will be adapted from big five personality scores and spatio-temporal location information. In Section IV we will show the results of the prediction and analyze the results. Section V will conclude this paper with directions of future research.

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II. Backgrounds

A. Big Five Personality Traits

In a domain of psychology, the Big Five factors (BFF) of personality are five broad domains that are used to describe human personality. The Big Five framework of personality traits emerged as a robust model for understanding the relationship between personality and various behaviors [7].

The Big Five factors are:

- Openness to experience (inventive vs. cautious)
- Conscientiousness (efficient vs. Careless)
- Extraversion (outgoing vs. solitary/reserved
- Agreeableness (friendly vs. unkind)
- Neuroticism (sensitive vs. secure/confident)

Personality traits were measured using the Big Five Inventory (BFI) that is a most frequently used self-report inventory [8], [9], [10] and the scores of five factors from BFI is treated as major inputs of algorithm developed in this paper.

B. Back Propagation Network

Back Propagation Network (BPN) is a kind of neural network developed by Parker in 1982 [11]. It has output layer, hidden layer, and input layer. Each layer can be composed of arbitrary number of nodes.

The nodes between each layer are connected and each connection edge has its own weight, so called connection strength. The error of output layer used to calibrate the connection strength between hidden layer and output layer, and the error of output layer is back propagated to hidden layer, then the connection weight between input layer and hidden layer will be calibrated.

In sum, repetitions of three steps required: input a leaning pattern and earning output, earning error between output and desired values, back propagate error to calibrate connection strength [12], [13]. This procedure will be finished once a desired error level is achieved.

The detailed process requires several parameters.

First, we must have V and W as connection strength, and initialize them.

Second, we must have p patterns.

Third, limitation of error, E_{max} , must be determined. Then the output of hidden layer, Z can be derived as follows:

$$NET_z = XV^T \quad (1)$$

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$$Z = f(NET_Z) = \frac{1}{1+e^{-NET_Z}} \quad (2)$$

Also, output *y* can be derived as:

$$NET_y = ZW^T \quad (3)$$

$$y = f(NET_y) = \frac{1}{1+e^{-NET_y}} \quad (4)$$

With the desired output *d*, we can calculate error *E*.

$$E = \frac{1}{2}(d-y)^2 \quad (5)$$

The error signal for hidden layer (δ_z) and output layer (δ_y) can be calculated

$$\delta_y = (d-y)y(1-y) \quad (6)$$

$$\delta_z = z(1-z)\sum_{i=1}^{m}\delta_y\omega \quad (7)$$

Then ΔW which stands for difference of connection strength between hidden layer and output layer can be applied to connection strength for next step, W_{k+1}.

$$\Delta W = \alpha\delta_y Z \quad (8)$$

$$W_{k+1} = W_k + \Delta W \quad (9)$$

Also ΔV and V_{k+1} can be derived with input *X*.

$$\Delta V = \alpha\delta_z X \quad (10)$$

$$V_{k+1} = V_k + \Delta V \quad (11)$$

Finally, E and E_{max} are compared in order to determine more repetitions or finish of the learning.

III. Experiment Design for Location Prediction

In this section, we will discuss about location prediction procedure. The relationship between human personality and human mobility is not yet clearly determined. There might be deterministic relationship functions for the relationship between human personality and human locations. Currently only probabilistic method can be presented between personality and mobility. Hitherto, either of deterministic or probabilistic method has not been presented. Regarding location, time, and personality as a pattern for a human, some sort of pattern learning method is required.

Several algorithms have been published for pattern learning or pattern recognition. Among them BPN [14] and Deep Belief Network (DBN) [15] are widely used. DBN is better than BPN in a manner that DBN provides more precise result since BPN tend to show local optima while DBN is proven to result in global optima. However DBN requires homogeneous data types both for input data and output data. In our research, BPN is a better fit than DBN. Therefore, BPN is used in order to combine BFF, time, and location information. For locations, *house (home), school, mountain, and etc.* were assumed as outstanding locations.

Table I shows a basic relationship between BFF and sample locations. Plus sign (+) stands for positive relationship between a factor and a location, while minus sign (-) stands for negative relationship [15], [16].

For example, person with high Agreeableness should has high tendency of personal relationship and thus affect positively on the locations such as school and mountain. As well, person with high Neuroticism should show tendency to be at house rather than mountain and etc. since the person tends to avoid external stimuli [17], [18].

Table II shows BFF scores according to each five factors. For example, a person who has values of openness as 3.21, conscientiousness as 3.346, extraversion as 3.134, agreeableness as 3.727, Neuroticism as 2.84 will be regarded as normal personality from the aspect of BFF.

Once a person has the highest 10% openness, the value will be 3.71 for the person and other values remain unchanged. Due to the orthogonality of five factors, any combination of five factor values is allowable without harming the generality of BFF [5].

These scores can be used as input values to BPN directly. Once BFF of a person is obtained, the factors will be an input of BPN.

Table III shows basic mobility model assuming normal personality. The term *normal* stands that every five personality factor for the person does not sit outside the normal level, i.e. the average personality. The leftmost column of Table III shows time information of a day in 24 hour representation. Original data stands for probabilities for the person be at the location at given time.

After applying BPN, the output shows trained data which sit on four right column of Table III. The location probability is calculated from a set of human mobility data set obtained by positioning devices [3], [19].

Tables III to XIII contain sample original data and trained data in this manner. Original data of each table will be used as inputs of BPN training.

Table IV to shows the original result and trained result with each personality factor exaggerated. The term exaggerated stands for highest 10% or lowest 10% of each personality. For example, Table IV has original data with lowest 10% extraversion. Italicized numbers show the location probability affected by low extraversion while original data of table 5 shows location probability calculated by high extraversion. Therefore total 11 tables will be presented and details will be discussed in section .

In case of a person with high openness, the corresponding location will be affected as shown in table 11 different from the average values in table 3. We calculated high factor affects the corresponding location probability to 130% while low factor affects the corresponding location probability to 70% of original location probability.

Algorithm 1 shows the overall procedure of location prediction. It has learning stage as a front stage and output stage as a back stage.

In learning stage, connection weight is set to be as random numbers. During the learning stage, connection weight converges to a certain vale.

Input node set 1 of BPN is time data and input node set 2

has personality score data. The learning stage finishes with threshold level of 0.5%.

Algorithm 1 Procedure for Personality-Location Prediction

Require: Sample data composed with Time, BFF, Location value
Require: Time data and BFF data of a Person

▷ Learning Stage

1: initialize Connect Weight using Random Value
2: **while** Number of Sample Data **do**
3: Input Node Set 1 ← Original Time Data
4: Input Node Set 2 ← Original BFF Data
5: **while** Error threshold with 0.5% of Output Layer value **do**
6: Modify Connection Weight by Back Propagation
7: Propagate from Input Layer to Output Layer
8: **end while**
9:**end while**

▷ Output Stage

10: Input Node Set 1 ← Personal time Data
11: Input Node Set 2 ← Personal BFF Data
12: Propagate from Input Layer to Output Layer
13: Print Out Put Layer's Node Data()

▷ Each of the Nodes stands for Location Data

TABLE I: ASSUMED IMPACT OF BIG FIVE PERSONALITY SCORES TO POSITION DATA

Personal Factor	House	School	Mountain	Etc.
Openness	0	0	+	+
Conscientiousness	+	+	+	+
Extraversion	0	0	-	+
Agreeableness	0	+	+	0
Neuroticism	+	0	-	-

TABLE II: TYPICAL PERSONALITY SCORES

Personality	Normal	Highest 10%	Lowest 10%
Openness	3.21	3.71	2.71
Conscientiousness	3.346	3.826	2.866
Extraversion	3.134	3.694	2.574
Agreeableness	3.727	4.227	3.227
Neuroticism	2.84	3.37	2.31

After the learning stage finished, output stage requires time data as input node set 1 and personality factor scores as input node set 2, and outputs the result. Output node has location weight of each location corresponding to personality factors.

In order to represent time data as inputs of BPN, we used angular representation of time. The degree of hour hand of a clock represents time in 24 hours. For example, degree 0 ° for 6'O clock, degree 180 ° for 18'O clock, and degree 240 ° for 12'O clock. Sine and cosine values of the clock degree are regarded as input values.

BPN for Algorithm 1 is designed as follows:

1) Input layer is consisted of 8 nodes: 2 for time data, 5 for big five personality scores and 1 for control as known as bias node.
2) Output layer is consisted of 4 nodes: Each node represents location weight for house, school, mountain, and etc., respectively.
3) Hidden layer is consisted of 12 nodes which is sum of the number of input nodes and the number of output nodes.

IV. EXPERIMENTAL RESULTS

Table XIV and XV show typical connection weights of BPN after learning process with sample input data of Table III to XIII. Table XIV shows connection weight between input layer and hidden layer and Table XV shows connection weight between hidden layer and output layer of BPN.

Once the connection weight values are set up, it is ready to have output from BPN with proper input data. Input nodes of BPN must have time data and big five personality score values. Then the output nodes will have location probability values calibrated by BFF and time. The first output node has values for house, the second output node has values for school, the third output node has values for mountain and the fourth output node has values for other places. For instance, if input nodes has time data of 45° standing for 3'O clock, and BFF values for normal personality then the output values will be 0.781381, 0.00188912, 0.0019602, 0.000108807 corresponding location weight for House, School, Mountain, Etc., respectively.

From Table III to XIII, values of original data column (sub columns 2-5) will be calibrated to values of trained data column (sub columns 6-9) representing location weight. For example Table XI shows personality with low neuroticism, and the trained value for house at 15'O clock will have location weight of 7.46E-17 which could be regarded as 0 considering the maximum weight can be up to 1. In other words, a person with low neuroticism will be at house at 15'O clock with very low probability.

Comparing Table VI and Table VIII, the effect of agreeableness on the location weight of school and mountain is represented in numerical values. Table VI shows calibration of position data under high agreeableness (highest 10%) and Table VII shows calibration of position data under low agreeableness and the effect of agreeableness on personal location is clear. Corresponding values are italicized. For example at 21'O clock, person with low agreeableness has location weight of 0.405378 at mountain while 0.215108 for person with low agreeableness. In case of the location 'mountain' at 21'O clock, Table III shows 0.299231 for normal personality. As we assumed the relationship between BFF and location as shown in Table I, openness affects positively and extraversion affects negatively on the location weight of mountain. With high openness as shown in Table XII, a location weight for a person to be at mountain at 21'O clock is 0.394049. According to the assumptions from Table I, it is clear that openness affects positively for a person to be at mountain and moreover the introduction of BPN enables us to calculate the quantitative weight numerically. On the other hand, a person with high neuroticism shows location weight of 0.216281 for mountain at 21'O clock as shown in Table X. Comparing to the case of normal personality as shown in Table III (0.299231), high neuroticism give negative effect on the location and the quantitative value is presented with the help of BPN.

V. CONCLUSION

The purpose of this study was to investigate whether information about individual personality trait would help to predict human mobility pattern. At first stage, the Big Five Inventory (BFI) was administered to get individual scores on five dimensions of personality traits. And, space-temporal information of locations was gathered and then analyzed in order to designate human mobility model. At the next stage,

the scores on five dimensions of BFI were prepared as inputs to BPN. On the other hand, human mobility information was probability values and thus directly regarded as nodes of BPN. In specific, time information was applied to BPN as input nodes and probability of locations is regarded as sample data in order to apply BPN based learning.

As a result, we identified that human personality trait helps to predict human location, which make it possible to model more detailed human mobility pattern. We also showed that the effect of human personality on human mobility pattern could be simulated with space-temporal representation of human mobility model.

Future research should focus on inverse mapping between human mobility pattern and human personality traits, which could enable us to infer one's personality traits by identifying an individual's regular mobility pattern. We hope that the more detailed relationship between the human personality and one's preferred locations could be clearly identified.

TABLE III: CALIBRATION OF POSITION DATA UNDER NORMAL PERSONALITY

	Original Data				Trained Data			
Time	**House**	**School**	**Mountain**	**Etc.**	**House**	**School**	**Mountain**	**Etc.**
0	1	0	0	0	0.977493	3.54E-09	0.035141	0.023443
1	1	0	0	0	0.995207	0.001889	0.00196	0.000109
2	0.75	0.25	0	0	0.781381	0.278627	0.00039	5.34E-06
3	0.5	0.5	0	0	0.5333	0.540584	0.000263	3.40E-06
4	0.2	0.8	0	0	0.219898	0.845313	0.00039	1.65E-05
5	0	1	0	0	0.004056	0.984315	0.001973	0.000879
6	0	1	0	0	4.89E-06	0.984059	0.025257	0.021082
7	0	0.8	0.1	0.1	9.51E-07	0.85132	0.118707	0.095778
8	0	0.6	0.2	0.2	1.89E-06	0.643785	0.296931	0.265309
9	0	0.2	0.4	0.4	2.15E-06	0.229157	0.507118	0.497134
10	0	0	0.6	0.4	1.52E-07	0.000485	0.697543	0.520416
11	0	0	0.8	0.2	7.28E-09	4.27E-07	0.873002	0.259694
12	0	0	1	0	8.94E-10	2.09E-09	0.963336	0.029043
13	0	0	1	0	2.81E-11	1.01E-11	0.975692	0.004057
14	0	0	1	0	4.37E-15	1.28E-14	0.962344	0.031269
15	0	0	0.8	0.2	1.55E-15	8.98E-16	0.859055	0.26923
16	0	0	0.6	0.4	1.85E-10	5.77E-14	0.633715	0.485245
17	0	0	0.4	0.6	1.03E-07	5.34E-11	0.426702	0.680094
18	0	0	0.2	0.8	0.000237	3.44E-11	0.217874	0.835416
19	0	0	0.2	0.6	0.031296	1.36E-12	0.192009	0.678497
20	0.2	0	0.2	0.4	0.179941	1.48E-13	0.23723	0.413636
21	0.2	0	0.3	0.3	0.228187	7.75E-14	0.299231	0.341147
22	0.2	0	0.3	0.3	0.190177	8.59E-14	0.322142	0.302684
23	0.3	0	0.2	0.2	0.305698	5.87E-13	0.204147	0.19442

TABLE IV: CALIBRATION OF POSITION DATA UNDER LOW EXTRAVERSION PERSONALITY

	Original Data				Trained Data			
Time	**House**	**School**	**Mountain**	**Etc.**	**House**	**School**	**Mountain**	**Etc.**
0	1	0	**0**	**0**	0.973411	2.91E-09	**0.052365**	**0.016897**
1	1	0	**0**	**0**	0.997236	0.001036	**0.002972**	**7.49E-05**
2	0.75	0.25	**0**	**0**	0.811606	0.268775	**0.000494**	**2.46E-06**
3	0.5	0.5	**0**	**0**	0.551068	0.544951	**0.000317**	**1.44E-06**
4	0.2	0.8	**0**	**0**	0.216143	0.833387	**0.000473**	**6.18E-06**
5	0	1	**0**	**0**	0.00195	0.987062	**0.002766**	**0.000297**
6	0	1	**0**	**0**	2.70E-06	0.986691	**0.033691**	**0.008283**
7	0	0.8	**0.13**	**0.07**	8.59E-07	0.854303	**0.137114**	**0.042747**
8	0	0.6	**0.26**	**0.14**	1.78E-06	0.657655	**0.333746**	**0.140581**
9	0	0.2	**0.52**	**0.28**	2.05E-06	0.247838	**0.591964**	**0.344232**
10	0	0	**0.78**	**0.28**	1.36E-07	0.000446	**0.854462**	**0.394423**
11	0	0	**1.04**	**0.14**	4.33E-09	1.49E-07	**0.984668**	**0.152886**
12	0	0	**1.3**	**0**	3.16E-10	2.30E-10	**0.999049**	**0.011384**
13	0	0	**1.3**	**0**	4.71E-12	5.03E-13	**0.999705**	**0.001914**
14	0	0	**1.3**	**0**	5.41E-16	5.61E-16	**0.999391**	**0.022921**
15	0	0	**1.04**	**0.14**	1.84E-15	1.03E-16	**0.989271**	**0.183089**
16	0	0	**0.78**	**0.28**	2.65E-10	1.53E-14	**0.842392**	**0.34064**
17	0	0	**0.52**	**0.42**	5.05E-08	3.28E-11	**0.529568**	**0.481387**
18	0	0	**0.26**	**0.56**	9.26E-05	2.54E-11	**0.256518**	**0.626456**
19	0	0	**0.26**	**0.42**	0.027284	7.06E-13	**0.209907**	**0.44592**
20	0.2	0	**0.26**	**0.28**	0.181484	1.18E-13	**0.289645**	**0.302289**
21	0.2	0	**0.39**	**0.21**	0.233029	8.34E-14	**0.389084**	**0.279813**
22	0.2	0	**0.39**	**0.21**	0.19605	1.04E-13	**0.42404**	**0.236496**
23	0.3	0	**0.26**	**0.14**	0.30919	7.18E-13	**0.275044**	**0.132774**

TABLE V: CALIBRATION OF POSITION DATA UNDER HIGH EXTRAVERSION PERSONALITY

	Original Data				Trained Data			
Time	**House**	**School**	**Mountain**	**Etc.**	**House**	**School**	**Mountain**	**Etc.**
0	1	0	**0**	**0**	0.980157	4.49E-09	**0.02253**	**0.029223**
1	1	0	**0**	**0**	0.991519	0.003019	**0.001301**	**0.00016**
2	0.75	0.25	**0**	**0**	0.755895	0.280352	**0.000309**	**1.14E-05**
3	0.5	0.5	**0**	**0**	0.517921	0.538293	**0.00022**	**7.92E-06**
4	0.2	0.8	**0**	**0**	0.216765	0.861283	**0.000328**	**4.32E-05**
5	0	1	**0**	**0**	0.007146	0.982661	**0.00147**	**0.002476**
6	0	1	**0**	**0**	9.93E-06	0.978888	**0.018376**	**0.051174**
7	0	0.8	**0.07**	**0.13**	1.09E-06	0.842411	**0.099724**	**0.194052**
8	0	0.6	**0.14**	**0.26**	1.96E-06	0.621683	**0.256638**	**0.425881**
9	0	0.2	**0.28**	**0.52**	2.15E-06	0.20015	**0.430315**	**0.629217**
10	0	0	**0.42**	**0.52**	1.52E-07	0.000427	**0.560218**	**0.617837**
11	0	0	**0.56**	**0.26**	9.22E-09	6.86E-07	**0.671427**	**0.364705**
12	0	0	**0.7**	**0**	1.62E-09	7.85E-09	**0.770232**	**0.060376**
13	0	0	**0.7**	**0**	9.42E-11	7.73E-11	**0.748445**	**0.008081**
14	0	0	**0.7**	**0**	2.35E-14	1.28E-13	**0.702208**	**0.040894**
15	0	0	**0.56**	**0.26**	1.25E-15	4.39E-15	**0.602887**	**0.368399**
16	0	0	**0.42**	**0.52**	1.09E-10	1.69E-13	**0.502879**	**0.632733**
17	0	0	**0.28**	**0.78**	2.18E-07	7.54E-11	**0.366008**	**0.828974**
18	0	0	**0.14**	**1.04**	0.000488	4.90E-11	**0.196425**	**0.932521**
19	0	0	**0.14**	**0.78**	0.033065	2.45E-12	**0.178446**	**0.828382**
20	0.2	0	**0.14**	**0.52**	0.173706	1.80E-13	**0.195523**	**0.516649**
21	0.2	0	**0.21**	**0.39**	0.219716	7.20E-14	**0.226964**	**0.398936**
22	0.2	0	**0.21**	**0.39**	0.181888	7.18E-14	**0.235342**	**0.366378**
23	0.3	0	**0.14**	**0.26**	0.301953	4.92E-13	**0.144146**	**0.258378**

TABLE VI: CALIBRATION OF POSITION DATA UNDER HIGH AGREEABLENESS PERSONALITY

	Original Data				Trained Data			
Time	**House**	**School**	**Mountain**	**Etc.**	**House**	**School**	**Mountain**	**Etc.**
0	1	**0**	**0**	0	0.969293	**4.38E-09**	**0.054751**	0.021319
1	1	**0**	**0**	0	0.989333	**0.0028219**	**0.00285384**	9.76E-05
2	0.75	**0.325**	**0**	0	0.773835	**0.336836**	**0.000558304**	5.18E-06
3	0.5	**0.65**	**0**	0	0.560784	**0.628453**	**0.000364489**	3.27E-06
4	0.2	**1.04**	**0**	0	0.224495	**0.933357**	**0.00053506**	1.50E-05
5	0	**1.3**	**0**	0	0.0025821	**0.999024**	**0.00293492**	0.000727
6	0	**1.3**	**0**	0	3.38E-06	**0.999552**	**0.0365567**	0.017729
7	0	**1.04**	**0.13**	0.1	9.67E-07	**0.973814**	**0.158746**	0.090602
8	0	**0.78**	**0.26**	0.2	2.00E-06	**0.796906**	**0.380713**	0.26651
9	0	**0.26**	**0.52**	0.4	2.07E-06	**0.283927**	**0.629403**	0.501797
10	0	**0**	**0.78**	0.4	1.23E-07	**0.00043989**	**0.851397**	0.516982
11	0	**0**	**1.04**	0.2	4.93E-09	**2.70E-07**	**0.977667**	0.242828
12	0	**0**	**1.3**	0	4.71E-10	**7.92E-10**	**0.998**	0.0236719
13	0	**0**	**1.3**	0	1.41E-11	**3.47E-12**	**0.999171**	0.0030069
14	0	**0**	**1.3**	0	2.40E-15	**8.39E-15**	**0.998131**	0.0223745
15	0	**0**	**1.04**	0.2	4.41E-16	**3.11E-15**	**0.97769**	0.216045
16	0	**0**	**0.78**	0.4	6.47E-11	**1.21E-12**	**0.806597**	0.416771
17	0	**0**	**0.52**	0.6	5.15E-08	**5.17E-10**	**0.542167**	0.626745
18	0	**0**	**0.26**	0.8	0.00012663	**9.06E-11**	**0.289029**	0.803918
19	0	**0**	**0.26**	0.6	0.0277301	**1.71E-12**	**0.245746**	0.646589
20	0.2	**0**	**0.26**	0.4	0.177271	**1.75E-13**	**0.313287**	0.401897
21	0.2	**0**	**0.39**	0.3	0.229213	**9.53E-14**	**0.405378**	0.340237
22	0.2	**0**	**0.39**	0.3	0.193584	**1.09E-13**	**0.44559**	0.30325
23	0.3	**0**	**0.26**	0.2	0.303512	**7.25E-13**	**0.303667**	0.191761

TABLE VII: CALIBRATION OF POSITION DATA UNDER LOW AGREEABLENESS PERSONALITY

	Original Data				Trained Data			
Time	**House**	**School**	**Mountain**	**Etc.**	**House**	**School**	**Mountain**	**Etc.**
0	1	**0**	**0**	0	0.982515	**2.83E-09**	**0.021512**	0.0256231
1	1	**0**	**0**	0	0.997916	**0.00121072**	**0.00129543**	0.000121141
2	0.75	**0.175**	**0**	0	0.795212	**0.216423**	**0.000262805**	5.50E-06
3	0.5	**0.35**	**0**	0	0.507059	**0.415727**	**0.000184539**	3.54E-06
4	0.2	**0.56**	**0**	0	0.213507	**0.585816**	**0.000278199**	1.84E-05
5	0	**0.7**	**0**	0	0.00608414	**0.688675**	**0.00131189**	0.00108037
6	0	**0.7**	**0**	0	7.48E-06	**0.711278**	**0.0165737**	0.0246888
7	0	**0.56**	**0.07**	0.1	9.45E-07	**0.596054**	**0.0842008**	0.0992426
8	0	**0.42**	**0.14**	0.2	1.78E-06	**0.508366**	**0.218464**	0.261852
9	0	**0.14**	**0.28**	0.4	2.20E-06	**0.191826**	**0.384438**	0.490133
10	0	**0**	**0.42**	0.4	1.79E-07	**0.000511089**	**0.524197**	0.520228
11	0	**0**	**0.56**	0.2	9.38E-09	**5.41E-07**	**0.652796**	0.271378
12	0	**0**	**0.7**	0	1.37E-09	**3.87E-09**	**0.772557**	0.0341656
13	0	**0**	**0.7**	0	4.41E-11	**2.09E-11**	**0.782694**	0.00524504
14	0	**0**	**0.7**	0	6.47E-15	**1.67E-14**	**0.762067**	0.0416324
15	0	**0**	**0.56**	0.2	4.91E-15	**3.37E-16**	**0.635616**	0.319722
16	0	**0**	**0.42**	0.4	4.57E-10	**3.21E-15**	**0.498092**	0.549401
17	0	**0**	**0.28**	0.6	2.13E-07	**2.76E-12**	**0.341458**	0.735158
18	0	**0**	**0.14**	0.8	0.000413816	**9.61E-12**	**0.169374**	0.864418
19	0	**0**	**0.14**	0.6	0.0343744	**9.90E-13**	**0.153444**	0.710106
20	0.2	**0**	**0.14**	0.4	0.181154	**1.23E-13**	**0.180234**	0.426879
21	0.2	**0**	**0.21**	0.3	0.225877	**6.28E-14**	**0.215108**	0.34325
22	0.2	**0**	**0.21**	0.3	0.185761	**6.74E-14**	**0.219703**	0.302769
23	0.3	**0**	**0.14**	0.2	0.305305	**4.70E-13**	**0.128412**	0.196992

TABLE VIII: CALIBRATION OF POSITION DATA UNDER HIGH CONSCIENTIOUSNESS PERSONALITY

	Original Data				Trained Data			
Time	**House**	**School**	**Mountain**	**Etc.**	**House**	**School**	**Mountain**	**Etc.**
0	**1.3**	**0**	**0**	**0**	**0.996448**	**5.62E-09**	**0.0550752**	**0.0317469**
1	**1.3**	**0**	**0**	**0**	**0.999865**	**0.00255227**	**0.00336248**	**0.00018765**
2	**0.975**	**0.325**	**0**	**0**	**0.916374**	**0.349212**	**0.000663**	**1.16E-05**
3	**0.65**	**0.65**	**0**	**0**	**0.632816**	**0.66455**	**0.000432853**	**7.55E-06**
4	**0.26**	**1.04**	**0**	**0**	**0.273073**	**0.944628**	**0.000634085**	**3.87E-05**
5	**0**	**1.3**	**0**	**0**	**0.00540717**	**0.998737**	**0.00316265**	**0.00203625**
6	**0**	**1.3**	**0**	**0**	**6.89E-06**	**0.999269**	**0.0397321**	**0.0431339**
7	**0**	**1.04**	**0.13**	**0.13**	**1.36E-06**	**0.969806**	**0.180784**	**0.186712**
8	**0**	**0.78**	**0.26**	**0.26**	**2.60E-06**	**0.79692**	**0.407026**	**0.432744**
9	**0**	**0.26**	**0.52**	**0.52**	**2.63E-06**	**0.299701**	**0.627072**	**0.640886**
10	**0**	**0**	**0.78**	**0.52**	**1.53E-07**	**0.000532234**	**0.831116**	**0.628079**
11	**0**	**0**	**1.04**	**0.26**	**5.79E-09**	**3.83E-07**	**0.972028**	**0.369487**
12	**0**	**0**	**1.3**	**0**	**6.06E-10**	**1.78E-09**	**0.997459**	**0.0618291**
13	**0**	**0**	**1.3**	**0**	**2.64E-11**	**1.15E-11**	**0.998888**	**0.00851724**
14	**0**	**0**	**1.3**	**0**	**9.97E-15**	**2.90E-14**	**0.9974**	**0.0453233**
15	**0**	**0**	**1.04**	**0.26**	**1.42E-14**	**4.11E-15**	**0.976013**	**0.403861**
16	**0**	**0**	**0.78**	**0.52**	**7.28E-10**	**1.34E-12**	**0.818089**	**0.661849**
17	**0**	**0**	**0.52**	**0.78**	**1.46E-07**	**7.29E-10**	**0.556088**	**0.845423**
18	**0**	**0**	**0.26**	**1.04**	**0.00027913**	**1.69E-10**	**0.302845**	**0.940727**
19	**0**	**0**	**0.26**	**0.78**	**0.0322448**	**3.83E-12**	**0.25467**	**0.839011**
20	**0.26**	**0**	**0.26**	**0.52**	**0.184738**	**2.40E-13**	**0.286688**	**0.518015**
21	**0.26**	**0**	**0.39**	**0.39**	**0.242518**	**9.77E-14**	**0.353551**	**0.390814**
22	**0.26**	**0**	**0.39**	**0.39**	**0.217915**	**1.03E-13**	**0.395508**	**0.353752**
23	**0.39**	**0**	**0.26**	**0.26**	**0.411769**	**7.26E-13**	**0.284126**	**0.251449**

TABLE IX: CALIBRATION OF POSITION DATA UNDER LOW CONSCIENTIOUSNESS PERSONALITY

	Original Data				Trained Data			
Time	**House**	**School**	**Mountain**	**Etc.**	**House**	**School**	**Mountain**	**Etc.**
0	**0.7**	**0**	**0**	**0**	**0.753958**	**2.21E-09**	**0.0189216**	**0.0138238**
1	**0.7**	**0**	**0**	**0**	**0.767109**	**0.00117025**	**0.00103332**	**5.77E-05**
2	**0.525**	**0.175**	**0**	**0**	**0.542766**	**0.191944**	**0.00021295**	**2.29E-06**
3	**0.35**	**0.35**	**0**	**0**	**0.423943**	**0.358046**	**0.000150965**	**1.47E-06**
4	**0.14**	**0.56**	**0**	**0**	**0.172721**	**0.479658**	**0.000228182**	**6.85E-06**
5	**0**	**0.7**	**0**	**0**	**0.00302008**	**0.625225**	**0.00117242**	**0.00036585**
6	**0**	**0.7**	**0**	**0**	**3.32E-06**	**0.707138**	**0.0149319**	**0.00938345**
7	**0**	**0.56**	**0.07**	**0.07**	**6.21E-07**	**0.560203**	**0.0693535**	**0.0403772**
8	**0**	**0.42**	**0.14**	**0.14**	**1.25E-06**	**0.471694**	**0.186478**	**0.119979**
9	**0**	**0.14**	**0.28**	**0.28**	**1.59E-06**	**0.167449**	**0.359615**	**0.295831**
10	**0**	**0**	**0.42**	**0.28**	**1.36E-07**	**0.000389456**	**0.516743**	**0.346903**
11	**0**	**0**	**0.56**	**0.14**	**7.90E-09**	**3.37E-07**	**0.620659**	**0.129515**
12	**0**	**0**	**0.7**	**0**	**1.09E-09**	**1.54E-09**	**0.707565**	**0.00935376**
13	**0**	**0**	**0.7**	**0**	**2.22E-11**	**5.90E-12**	**0.72755**	**0.00167648**
14	**0**	**0**	**0.7**	**0**	**1.56E-15**	**4.54E-15**	**0.730231**	**0.0211083**
15	**0**	**0**	**0.56**	**0.14**	**1.65E-16**	**2.10E-16**	**0.571959**	**0.161123**
16	**0**	**0**	**0.42**	**0.28**	**1.96E-11**	**1.99E-15**	**0.432881**	**0.301985**
17	**0**	**0**	**0.28**	**0.42**	**5.92E-08**	**1.31E-12**	**0.308406**	**0.435983**
18	**0**	**0**	**0.14**	**0.56**	**0.000187705**	**3.36E-12**	**0.141092**	**0.555917**
19	**0**	**0**	**0.14**	**0.42**	**0.0290587**	**3.05E-13**	**0.127491**	**0.376656**
20	**0.14**	**0**	**0.14**	**0.28**	**0.169297**	**7.42E-14**	**0.180059**	**0.273988**
21	**0.14**	**0**	**0.21**	**0.21**	**0.206429**	**5.62E-14**	**0.235021**	**0.269625**
22	**0.14**	**0**	**0.21**	**0.21**	**0.154466**	**6.79E-14**	**0.235911**	**0.228958**
23	**0.21**	**0**	**0.14**	**0.14**	**0.185705**	**4.59E-13**	**0.124185**	**0.122857**

TABLE X: CALIBRATION OF POSITION DATA UNDER HIGH NEUROTICISM PERSONALITY

	Original Data				Trained Data			
Time	**House**	**School**	**Mountain**	**Etc.**	**House**	**School**	**Mountain**	**Etc.**
0	**1.3**	0	**0**	**0**	**0.996614**	3.27E-09	**0.0254052**	**0.0121452**
1	**1.3**	0	**0**	**0**	**0.999956**	0.00126231	**0.00174705**	**5.84E-05**
2	**0.975**	0.25	**0**	**0**	**0.940008**	0.262101	**0.000363181**	**3.05E-06**
3	**0.65**	0.5	**0**	**0**	**0.631578**	0.551342	**0.000255618**	**1.96E-06**
4	**0.26**	0.8	**0**	**0**	**0.277116**	0.846815	**0.000391497**	**9.29E-06**
5	**0**	1	**0**	**0**	**0.00495457**	0.984484	**0.00203146**	**0.00048581**
6	**0**	1	**0**	**0**	**5.85E-06**	0.984447	**0.0251629**	**0.0122533**
7	**0**	0.8	**0.07**	**0.07**	**1.19E-06**	0.850784	**0.107822**	**0.0595709**
8	**0**	0.6	**0.14**	**0.14**	**2.27E-06**	0.630019	**0.248152**	**0.185611**
9	**0**	0.2	**0.28**	**0.28**	**2.43E-06**	0.200246	**0.403895**	**0.403509**
10	**0**	0	**0.42**	**0.28**	**1.66E-07**	0.000372238	**0.544731**	**0.441348**
11	**0**	0	**0.56**	**0.14**	**8.79E-09**	3.64E-07	**0.707029**	**0.200636**
12	**0**	0	**0.7**	**0**	**1.21E-09**	1.99E-09	**0.857481**	**0.0190226**
13	**0**	0	**0.7**	**0**	**4.98E-11**	1.17E-11	**0.886678**	**0.00243272**
14	**0**	0	**0.7**	**0**	**1.70E-14**	1.65E-14	**0.859661**	**0.0183923**
15	**0**	0	**0.56**	**0.14**	**7.97E-14**	5.05E-16	**0.726523**	**0.219936**
16	**0**	0	**0.42**	**0.28**	**1.51E-09**	3.09E-14	**0.515626**	**0.417017**
17	**0**	0	**0.28**	**0.42**	**1.32E-07**	3.52E-11	**0.337896**	**0.587912**
18	**0**	0	**0.14**	**0.56**	**0.000232095**	2.26E-11	**0.160454**	**0.755047**
19	**0**	0	**0.14**	**0.42**	**0.0338594**	8.84E-13	**0.137067**	**0.575177**
20	**0.26**	0	**0.14**	**0.28**	**0.199698**	1.14E-13	**0.171602**	**0.34586**
21	**0.26**	0	**0.21**	**0.21**	**0.262027**	6.52E-14	**0.216281**	**0.286824**
22	**0.26**	0	**0.21**	**0.21**	**0.237211**	7.56E-14	**0.231154**	**0.239153**
23	**0.39**	0	**0.14**	**0.14**	**0.433572**	5.41E-13	**0.142824**	**0.132246**

TABLE XI: CALIBRATION OF POSITION DATA UNDER LOW NEUROTICISM PERSONALITY

	Original Data				Trained Data			
Time	**House**	**School**	**Mountain**	**Etc.**	**House**	**School**	**Mountain**	**Etc.**
0	**0.7**	0	**0**	**0**	**0.714863**	4.28E-09	**0.0435225**	**0.0439002**
1	**0.7**	0	**0**	**0**	**0.725786**	0.00254048	**0.00206843**	**0.00020869**
2	**0.525**	0.25	**0**	**0**	**0.573618**	0.273453	**0.000399031**	**9.56E-06**
3	**0.35**	0.5	**0**	**0**	**0.445279**	0.52273	**0.000257188**	**5.94E-06**
4	**0.14**	0.8	**0**	**0**	**0.172826**	0.841448	**0.000369235**	**2.95E-05**
5	**0**	1	**0**	**0**	**0.00331928**	0.983816	**0.00181652**	**0.00160493**
6	**0**	1	**0**	**0**	**4.08E-06**	0.98313	**0.0237594**	**0.0365969**
7	**0**	0.8	**0.1**	**0.1**	**7.50E-07**	0.846769	**0.121613**	**0.153138**
8	**0**	0.6	**0.2**	**0.2**	**1.54E-06**	0.646688	**0.330357**	**0.368393**
9	**0**	0.2	**0.4**	**0.4**	**1.86E-06**	0.251361	**0.590308**	**0.593905**
10	**0**	0	**0.6**	**0.4**	**1.35E-07**	0.000600226	**0.812905**	**0.599368**
11	**0**	0	**0.8**	**0.2**	**5.77E-09**	4.64E-07	**0.955867**	**0.327682**
12	**0**	0	**1**	**0**	**6.21E-10**	2.00E-09	**0.99309**	**0.0440304**
13	**0**	0	**1**	**0**	**1.49E-11**	7.90E-12	**0.996364**	**0.00693385**
14	**0**	0	**1**	**0**	**1.40E-15**	9.05E-15	**0.993064**	**0.05435**
15	**0**	0	**0.8**	**0.2**	**7.46E-17**	1.36E-15	**0.947611**	**0.336031**
16	**0**	0	**0.6**	**0.4**	**7.24E-12**	1.30E-13	**0.75668**	**0.553189**
17	**0**	0	**0.4**	**0.6**	**5.83E-08**	8.78E-11	**0.540055**	**0.763869**
18	**0**	0	**0.2**	**0.8**	**0.000221924**	5.46E-11	**0.303785**	**0.894711**
19	**0**	0	**0.2**	**0.6**	**0.0277008**	2.13E-12	**0.275456**	**0.768263**
20	**0.14**	0	**0.2**	**0.4**	**0.156446**	1.97E-13	**0.33169**	**0.488543**
21	**0.14**	0	**0.3**	**0.3**	**0.190212**	9.31E-14	**0.407009**	**0.405323**
22	**0.14**	0	**0.3**	**0.3**	**0.14123**	9.73E-14	**0.427091**	**0.379994**
23	**0.21**	0	**0.2**	**0.2**	**0.168847**	6.40E-13	**0.270768**	**0.278651**

TABLE XII: CALIBRATION OF POSITION DATA UNDER HIGH OPENNESS PERSONALITY

	Original Data				Trained Data			
Time	**House**	**School**	**Mountain**	**Etc.**	**House**	**School**	**Mountain**	**Etc.**
0	1	0	**0**	**0**	0.972719	4.43E-09	**0.0598178**	**0.0463848**
1	1	0	**0**	**0**	0.990978	0.00302263	**0.00320741**	**0.000263366**
2	0.75	0.25	**0**	**0**	0.792897	0.33366	**0.000640916**	**1.54E-05**
3	0.5	0.5	**0**	**0**	0.580281	0.591628	**0.000416209**	**9.83E-06**
4	0.2	0.8	**0**	**0**	0.241951	0.86888	**0.000608359**	**4.97E-05**
5	0	1	**0**	**0**	0.00392562	0.98509	**0.00320462**	**0.00274273**
6	0	1	**0**	**0**	5.17E-06	0.982151	**0.0409495**	**0.0610953**
7	0	0.8	**0.13**	**0.13**	1.19E-06	0.853262	**0.18294**	**0.239878**
8	0	0.6	**0.26**	**0.26**	2.34E-06	0.670003	**0.420065**	**0.493714**
9	0	0.2	**0.52**	**0.52**	2.34E-06	0.237271	**0.656896**	**0.680829**
10	0	0	**0.78**	**0.52**	1.32E-07	0.000417607	**0.864347**	**0.659118**
11	0	0	**1.04**	**0.26**	5.11E-09	3.34E-07	**0.982243**	**0.407318**
12	0	0	**1.3**	**0**	5.18E-10	1.55E-09	**0.998699**	**0.0782159**
13	0	0	**1.3**	**0**	1.80E-11	8.00E-12	**0.999481**	**0.0125709**
14	0	0	**1.3**	**0**	3.37E-15	1.15E-14	**0.99874**	**0.0737991**
15	0	0	**1.04**	**0.26**	5.43E-16	9.58E-16	**0.984287**	**0.480167**
16	0	0	**0.78**	**0.52**	8.21E-11	7.76E-14	**0.856411**	**0.731697**
17	0	0	**0.52**	**0.78**	8.41E-08	1.22E-10	**0.624926**	**0.884548**
18	0	0	**0.26**	**1.04**	0.000208571	1.23E-10	**0.360437**	**0.953085**
19	0	0	**0.26**	**0.78**	0.0302757	3.62E-12	**0.292492**	**0.856477**
20	0.2	0	**0.26**	**0.52**	0.175625	2.40E-13	**0.323368**	**0.540579**
21	0.2	0	**0.39**	**0.39**	0.223837	9.95E-14	**0.394049**	**0.416095**
22	0.2	0	**0.39**	**0.39**	0.187475	1.03E-13	**0.434422**	**0.389023**
23	0.3	0	**0.26**	**0.26**	0.297354	6.62E-13	**0.311379**	**0.298001**

TABLE XIII: CALIBRATION OF POSITION DATA UNDER LOW OPENNESS PERSONALITY

	Original Data				Trained Data			
Time	**House**	**School**	**Mountain**	**Etc.**	**House**	**School**	**Mountain**	**Etc.**
0	1	0	**0**	**0**	0.979537	2.77E-09	**0.0191225**	**0.010398**
1	1	0	**0**	**0**	0.997485	0.00113747	**0.00115762**	**4.37E-05**
2	0.75	0.25	**0**	**0**	0.778789	0.227455	**0.000236199**	**1.95E-06**
3	0.5	0.5	**0**	**0**	0.494338	0.490276	**0.000168959**	**1.29E-06**
4	0.2	0.8	**0**	**0**	0.204757	0.819252	**0.00025546**	**6.12E-06**
5	0	1	**0**	**0**	0.00432038	0.983437	**0.00124158**	**0.000311279**
6	0	1	**0**	**0**	4.80E-06	0.985893	**0.0156071**	**0.00763702**
7	0	0.8	**0.07**	**0.07**	7.70E-07	0.849986	**0.0738769**	**0.0349285**
8	0	0.6	**0.14**	**0.14**	1.49E-06	0.610495	**0.190271**	**0.110511**
9	0	0.2	**0.28**	**0.28**	1.87E-06	0.20886	**0.348389**	**0.283612**
10	0	0	**0.42**	**0.28**	1.59E-07	0.000468578	**0.487315**	**0.335221**
11	0	0	**0.56**	**0.14**	8.57E-09	3.52E-07	**0.586643**	**0.120962**
12	0	0	**0.7**	**0**	1.20E-09	1.59E-09	**0.680448**	**0.00827813**
13	0	0	**0.7**	**0**	3.44E-11	8.21E-12	**0.699521**	**0.00128495**
14	0	0	**0.7**	**0**	4.70E-15	1.05E-14	**0.698773**	**0.0143437**
15	0	0	**0.56**	**0.14**	4.14E-15	7.14E-16	**0.568207**	**0.145037**
16	0	0	**0.42**	**0.28**	3.61E-10	4.45E-14	**0.424406**	**0.276241**
17	0	0	**0.28**	**0.42**	1.24E-07	2.50E-11	**0.27663**	**0.400144**
18	0	0	**0.14**	**0.56**	0.000261672	9.26E-12	**0.123686**	**0.546752**
19	0	0	**0.14**	**0.42**	0.0311497	4.36E-13	**0.116381**	**0.379134**
20	0.2	0	**0.14**	**0.28**	0.179711	8.35E-14	**0.165167**	**0.268538**
21	0.2	0	**0.21**	**0.21**	0.228141	5.85E-14	**0.216457**	**0.256706**
22	0.2	0	**0.21**	**0.21**	0.188296	7.06E-14	**0.22048**	**0.211645**
23	0.3	0	**0.14**	**0.14**	0.304665	5.11E-13	**0.119578**	**0.107596**

TABLE XV: CONNECTION WEIGHT FROM INPUT LAYER TO HIDDEN LAYER WITH PERSONALITY TRAITS

	1	2	3	4	5	6	7	8	9	10	11	12
1	6.0261	2.75965	-0.0749	5.98229	-3.1383	1.10546	-0.4349	0.80729	-15.104	-1.0126	0.23002	-3.3849
2	1.62893	7.89546	1.14312	8.44594	-6.3831	-4.1631	-0.4166	-7.9405	-2.1986	1.60607	-1.8675	-2.6380
3	-5.6551	-2.5238	-8.5787	-5.2857	-0.8316	-3.5634	6.22166	-2.2357	-7.0541	1.32888	-0.6386	2.07263
4	-0.5323	2.33302	-3.5212	2.49804	1.24815	-2.4662	-0.9831	0.57963	-7.6469	1.39708	2.04455	3.26793
5	-5.3098	0.44011	2.32366	1.90843	0.08155	0.43700	0.17753	0.60137	6.04728	-0.7263	-2.3050	3.33157
6	-5.2172	2.0683	-0.2592	-4.8087	1.81606	-3.4538	-0.8815	0.23963	5.92729	-0.6877	-0.7459	-1.2541
7	0.17610	0.96288	0.50780	-6.6159	-0.4836	1.06806	0.27494	0.32268	-2.5	-1.7525	2.95478	0.32965
8	0.89528	0.79300	0.80834	1.99752	1.81771	-3.9273	-0.5789	0.56145	6.16726	0.34576	-1.9315	-0.6644

TABLE XVI: CONNECTION WEIGHT FROM HIDDEN LAYER TO OUTPUT LAYER WITH PERSONALITY TRAITS

	1	2	3	4
1	0.44607	24.1901	0.216048	0.966789
2	20.9234	12.6088	-2.79373	-9.12836
3	-12.0684	8.68411	2.61001	-0.685407
4	-23.1581	3.52399	-0.781994	-0.681711
5	-1.89288	-2.03859	1.74608	-0.182466
6	1.79462	2.0692	-4.80241	0.33177
7	5.33447	-14.1656	-1.80838	-11.3258
8	-7.91766	-14.0847	0.500924	-1.0714
9	-6.84025	-13.6281	28.324	-1.30922
10	-7.04352	-5.11401	-6.98142	6.5911
11	0.738434	-3.06309	-7.71258	-0.865423
12	3.94231	2.19236	4.70027	12.0352

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