Personal Credit Evaluation System through Telephone Voice Analysis: By Support Vector Machine[☆]

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요 약

인간의 목소리는 사람간의 정보 전달을 위한 가장 쉬운 방법 중 하나이다. 음성의 특징은 사람마다 다를 수 있으며 발성 속도, 발성기관의 형태와 기능, 피치 톤, 언어 습관 및 성별에 따라 다르게 나타난다. 목소리는 사람의 의사소통 핵심 요소이다. 제 4 차 산업 혁명의 시대에 목소리는 사람과 사람, 사람과 기계, 기계 와 기계 사이의 주요한 의사소통 수단이 된다. 그 이유 때문에 사람들은 자신의 의도를 다른 사람들에게 명확하게 전달하려고 노력한다. 그리고 이 과정에서 목소리는 언어 정보와 함께 다양한 추가 정보가 포함되게 된다. 예를 들어 감정 상태, 건강 상태, 신뢰도와 관련되거나, 거짓말의 여부, 음주로 인한 목소리의 변화 등 다양한 언어 및 비언어 정보를 포함하며, 다양한 분석 파라미터로 나타나게 된다. 이를 활용하면 개인의 신용도를 평가하는 척도로 사용할 수 있다. 특히 성대의 기본 주파수의 특성과 성도의 공진 주파수 특성의 관계를 분석함으로써 얻을 수 있다. 이전의 연구에서 다양한 신용 상태의 변화에 따른 목소리 분석 및 특성 변화를 연구 하였다. 본 연구에서는 음성을 통해 추출 된 매개 변수를 통해 기계 학습을 통한 개인 신용 판별 기를 제안한다.

☞ 주제어 : 음성분석, 목소리 신용척도, 음성특성, 기계학습, 서포트 벡터 머신

ABSTRACT

The human voice is one of the easiest methods for the information transmission between human beings. The characteristics of voice can vary from person to person and include the speed of speech, the form and function of the vocal organ, the pitch tone, speech habits, and gender. The human voice is a key element of human communication. In the days of the Fourth Industrial Revolution, voices are also a major means of communication between humans and humans, between humans and machines, machines and machines. And for that reason, people are trying to communicate their intentions to others clearly. And in the process, it contains various additional information along with the linguistic information. The Information such as emotional status, health status, part of trust, presence of a lie, change due to drinking, etc. These linguistic and non-linguistic information can be used as a device for evaluating the individual's credit worthiness by appearing in various parameters through voice analysis. Especially, it can be obtained by analyzing the relationship between the characteristics of the fundamental frequency(basic tonality) of the vocal cords, and the characteristics of the resonance frequency of the vocal track.In the previous research, the necessity of various methods of credit evaluation and the characteristic change of the voice according to the change of credit status were studied. In this study, we propose a personal credit discriminator by machine learning through parameters extracted through voice.

☞ keyword : Voice analysis, Voice credit rating, Voice characteristics, Machine learning, Support vector machine

1. Introduction

A person's voice is one of the easiest and most important ways of communicating information between people and between people and between people and machines. These voices are generated through the human vocal apparatus and spread out into the air. The voices created by the vocal organs enable basic communication, and once created, voices

are spread out through the air and then disappear, normally. At this time, the voices are created together with the linguistic communication, information, and the individual characteristics of the person who created it. In the process of making the voices, similar results are obtained by analyzing the characteristics of the vocal organs corresponding to the characteristics of the individual, the spatial, which is place who are live, characteristics of the language, the personality, the health, and the psychological state. Analyzing the voices, similar features remain in the form of sounds with meaning by language, and similar features are caused by different causes for individuals [1]. As people's voices have been used to communicate information in a variety of ways, IT has evolved to record these voices long ago or to deliver them far. Today, by analyzing the information of voices, the machine sets the direction of people and machines by performing human commands, recording information, and judging psychology [1-3].

There are parameters in the voices that give different characteristics to each individual in the process of being created. This is a different sound because the appearance and characteristics of the vocal organs are different, as individual faces look different, that depends on the sound generation process and resonance characteristics. In addition, the vocal habits, the linguistic structure according to the vocabulary used, and the characteristics of the local language according to the living area are distinguished, resulting in changes in voices according to health and psychological state. And through the precise analysis of these voices, we can find out the difference. We analyze these individual voices and basically use the above-mentioned basic language-based information transfer function. In addition to basic information, it contains over a hundred additional features of voices, which can be analyzed and identified to identify health, psychological state, and can be used to determine the authenticity or credibility of a speaker [3][4].

As the development of information and communication technology, computers are used to process voices and various results can be obtained. First of all, there is a way to transmit a voice away from a communication device, or to store it using a storage device. Next, the meaning of the voice is analyzed, and the command and the operation of the machine can be performed through speech recognition. Next, a person

can recognize a person by talking in some form (speaker recognition), granting access through identification (speaker identification), or judging whether an important function is performed or not. In addition, the computer can synthesize a voice announcement, or transmit information generated by the machine to a person [5][6]. Today, it is difficult to handle the emotions of the speaker together when using techniques such as communication, storage, speech recognition, speaker identification, speaker recognition, and speech synthesis. However, as in the study of [5][6], studies have been attempted to add the nature of the synthesized language as in [6], as well as to add emotional parts of synthesizing speech. In [5], attempts have been made to differentiate the amount and form of information that recognizes and transmits emotions during speech recognition or communication [7].

In the era of the Fourth Industrial Revolution, artificial intelligence has a positive effect on the whole industry and technology is developing. In particular, deep learning is one method of machine learning that is rapidly improving performance and adding features, around the Google Deepmind challenge match on March 2016. And, the machine learning method combined with big data judged the area of artificial intelligence which was not judged by artificial intelligence before. Big data processing method, known as deep learning, is a set of machine learning algorithms that perform high level abstraction (summarizing key parameters in big data) through a combination of various nonlinear transformation techniques to the computer. However, machine learning method of deep learning requires lots of data, computing power to make a conclusion, and ultimately the resources to judge the result [1][3][4]. In this study, we use the support vector machine method which can produce effective results in small learning operations.

The support vector machine(SVM) is one of the fields of machine learning, and it is a method of supervised learning for pattern recognition and data analysis. Machine learning can be divided into supervised learning and unsupervised learning. The advantage of supervised learning is that the results of the prediction are relatively accurate, even in less computational learning, and that it is possible to make a quick decision because it uses a small amount of data. SVM is a method of classifying data by looking for a linear

decision boundary (hyperplane) that distinguishes all data points of one class from data points of another class. And this SVM has very high classification accuracy. The reason for the high accuracy is that the margins between the data points to be classified are maximized, and the problem of overfitting occurs less frequently. Also, it is easy to improve the judgment performance by using the kernel function when it is difficult to judge by the linear classification algorithm [8][9].

People are trying to make good voices for various reasons. The purpose is to communicate clearly their intentions to the people who are preparing for various speeches, personal conversations, sales, even interviews for their own occupations, and communicate the intended situation clearly [10][11]. And people use financial institutions for various reasons. The basic function of finance is to allow households, corporations, governments, financial institutions, etc. to obtain necessary funds through transactions and to manage the funds. The credit of individuals and institutions in financial institutions is very important information. The criterion for assessing credit worthiness is the degree to which the past transaction performance and form have been faithfully performed, the extent to which the willingness to repay the obligation, if any, and the degree of probability of default. In the field of finance and P2P finance, it has become very popular by adopting the latest technology, such as deep learning and psychological evaluation, based on credit evaluation [2][3]. In this study, we propose a personal credit classifier that can be used quickly, accurately and easily through voice analysis. In previous research, we have studied the parameters according to the change of credit in the voice. Previous studies have also examined changes in voice parameters before and after bankruptcy in relation to personal defaults in lending, and studies have also been conducted to further characterize these changes. Furthermore, we propose a personal credit evaluation module through these parameters and telephone consultation voice analysis using machine learning(SVM).

In Section 2, we have looked the basic voice generation and analysis, and support vector machines. In Section 3, we propose an SVM method for evaluating credit. In Section 4, we present the results of experiments. And in Section 5, we conclude.

2. Related works and basic algorithm reviews

2.1 Voice analysis

Speech communication basically starts from the concept that the speaker is trying to convey and it is done through the following process. The speaker changes the idea to be transmitted into a linguistic structure and selects appropriate words or words to represent the speaker's idea in this process. And then, It arranges the word order according to the grammar of a specific language, and performs processing that adds accent to the emphasis, intonation of the part caused by habit or dialect, intensification, change of pitch, and the like. Next, a brain command is issued to move the musculature related to the vocal organ and the position of the vocal track in order to form a desire pronunciation of voice. These commands are prepared in the vocal organs and the air flow from the lungs vibrate the vocal cords. The airflow with this oscillated, resonates with the vocal track, diffusing from the nose and mouth end. And generates a sound waveform corresponding to the speaker's intention [10][11]. This process is depicted in Figure 1.
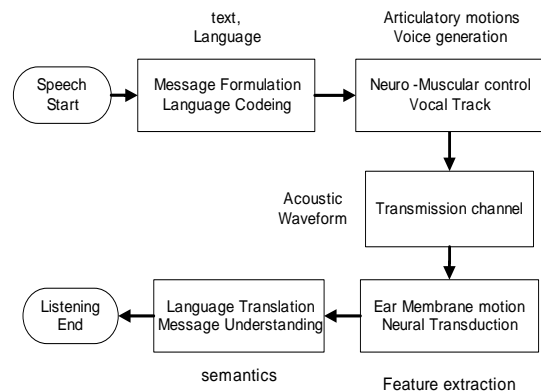
(Figure 1) Voice Generation flow diagram [11]

In the speech signal processing, the information of the voices can be roughly classified into the origin characteristic of the excitation source and the resonance characteristic of the vocal track parameter. First, the excitation source is caused by the presence or absence of vibrations of the vocal

cords, and the fundamental frequency that occurs when the vocal cords tremble are called pitches. This means that the vibration is determined by analyzing the number of times during the unit time or the period when the gate is opened and closed. When the pitch is accurately detected, the influence of the speaker at the time of speech recognition can be reduced, and the probability of speech synthesis can be maintained or the naturalness can be easily maintained. And we can change this to another voice. In general, for men, the pitch range that can be uttered is between 80 and 250 Hz. In the case of females, there is a characteristic that exists between 150 and 300Hz [10][12]. The change of the pitch with time can be regarded as a parameter of the main change of the voice, It is possible to evaluate whether the pitch change is retained in addition to the verbally contained information [4][12]. Second, the filtering parameter is a feature called formant. The formant frequencies in voices are frequency bands in which the air tremor generated in the vocal cords is emphasized by resonance as it passes through the vocal track. This formant frequency is expressed as a first, second formant or F1, F2 in order from low frequency. The position of the vertex is represented by frequency. Even though the sound caused by the air tremble generated in the excitation source is the same, the emphasized frequency band varies depending on the thickness, length, and rate of change [4][10][12].

In general, phonemic characteristics of phonemes are represented by F1 and F2. Concerning F3, F4, and F5 express individual characteristics of the speaker. When voice recognition is performed, F1 or F2 is important information in the voiced sound section. However, in the unvoiced section, the formant part is not simple and complicated unlike the voiced part, so that not only F1 and F2 but also F3, F4 and F5 include phonological information as well as other information. In addition, it can be confirmed by evaluating clear pronunciation and analyzing the inclination of the formant to convey information to the listener [11][12]. Thus, the position and slope of the first and second formant are obtained, and the slopes of the first and fourth formant are compared to confirm the confidence and clarity of the utterance as a whole. And we can use this formant frequency change as a parameter to measure speech speed [4].

2.2 Support vector machine

Support Vector Machine (SVM) is one of the algorithms used for machine learning analysis in the IT industry. SVM was developed on the basis of statistical analysis, the results of the algorithm are called dependent variables, and the factors that influence the results are called independent variables [8][9]. Statistical analysis is a method of predicting dependent variables by predicting the statistical similarity of independent variables in a large number of data [9][13]. That is, it can be said that it is a method of analyzing various conditions and statistically making a judgment criterion based on a large number and a small number [14]. In addition, SVM is a simple algorithm that finds hyper-planes that distinguish or predict dependent variables (decision results) through feature extraction from many data [15]. "SVM is a supervised learning models with associated learning algorithms that analyze data used for classification and regression analysis" [15]. SVM is an algorithm that can distinguish two categories as "as far as possible" when there are more than two categories in a dependent variable [16][17]. For example, an algorithm that distinguishes between ripe and unripe apples is achieved through machine learning and big data analysis. This SVM is well used in the field of machine learning because classification accuracy is very high. The reason for the high classification accuracy is that it maximizes the margin for the hyper-plane that separates dependent variables and reduces errors [18][19]. Usually, other predictors are learning to reduce errors, which in this case is overfitting, and SVM is less overfitting [20]. And it can improve the predictive performance by changing the dimension of data called kernel function, and it is easy to use when the characteristics of data are well known [21]. In this study, the hyper-plane is constructed by analyzing the changes of the voices generated during the process of financial consultation, whether the individuals are bankrupt or not, or the parameters of the voice change characteristics before and after the bankruptcy. So, SVM can make judgment. In addition, we are actively learning and changing hyper-planes during data analysis. The parameters obtained from the voice analysis mentioned in 2.1 are used as independent variables using judgment. The parameters used for judgment are as follows, fundamental frequency and

parameters of the change in pitch frequency, slope parameters according to formant location and size, parameters for speech rate, according to the time change of formant, and slope parameters according to energy change.

2.3 Finance and IT technology

FinTech is a combination of financial and technological, and refers to changes in financial services and industry through the convergence of finance and IT. The changes in financial services are technology-based financial service innovation that provides differentiated services from existing financial techniques by utilizing new IT technologies such as mobile, SNS, and big data. Recent examples include mobile banking and app cards. As the industry changes, there is a phenomenon that innovative non-financial companies provide financial services such as payment settlement directly to users by utilizing their own technologies. For example, bit-cone and Alipee [2]. According to U.K. Trade and Investments, the FinTech industry can be divided into two categories, Traditional and Emergent FinTech [2]. Emergent FinTech has five traditional financial service areas under way through many innovations [2]. New technology solutions can be differentiated in at least five areas: 1) the banking or insurance sector, 2) the solution with regards to their supported business processes, 3) the targeted customer segment, 4) the interactive form, and 5) the solutions that vary with regard to their market position [2][3]. Compared to traditional financing, fintech has a variety of fields such as payment, foreign exchange remittance, credit funding (kickstarter), P2P loans, P2B loans, asset management, Internet banking [2][3].

Peer-to-peer lending, also called P2P loan or social lending, is a method of debt financing between individuals and personal to companies via online services without official mediation agencies. By eliminating intermediaries from the process, it directly matches the borrower with the lending institution. However, increased ease of use and lower costs are more risky than loans from traditional financial institutions. P2P lenders are able to reduce operating costs by providing services solely through online. Therefore, they can provide services at a relatively lower cost than traditional financial institutions. As a result, the lender can earn higher profits than the financial instruments offered by traditional financial institutions, and the borrower is less likely than the existing bank You can get a loan at interest rate. The P2P platform itself can also earn money by charging fees for successful transactions. In other words, P2P lenders do not lend their own funds to the borrower. They act as facilitators for both borrowers and investors [2][3].

# 3. Propose personal credit evaluation system

The proposed personal credit rating system is as follows. When a voice is input through a telephone call, the user prepares the voice by processing such as noise. Then, in the corresponding voice, extract the parameters to be used as independent variables in the SVM. In addition, make sure that there are other arguments that you can use and classify them separately. And inputting parameters to the SVM discriminator to perform an individual's credit evaluation in a voice. The result shows us whether the telephone call is reliable or not. A block diagram of the proposed scheme is shown in Fig2. In the noise processing, a method of spectral subtraction is used for information which is ordinarily preprocessor. In the feature extraction, feature information obtained from the previous research was utilized. In previous research, we identified the voice elements that changed before and after the bankruptcy of individuals. Which are the formant slope, the pitch frequency and the speech speed etc.
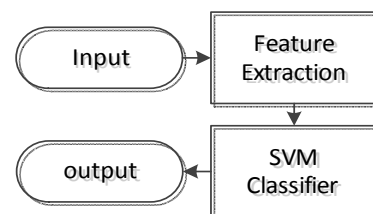
(Figure 2) Block diagram of proposed method

In the case of the pitch used as the judgment parameter of the SVM, the parameters are extracted by using the mean and variance of the pitch frequency over time rather than simply analyzing the frequency. Figure 3 shows the pitch contour diagram for 'ne' (mean is yes) utterance for speaker

independent. In the figure, the horizontal axis is the frame order and the vertical axis is the pitch frequency value. Figure 3 (a) shows the voice of a normal debtor who has not caused a default. Figure 3 (b) shows the result of the person who caused the default. In Fig. 3 (a), the pitch change rate is low and the pitch is evenly analyzed. In Fig. 3 (b), the change in pitch is relatively high and the variance is expected to be high.

a)

b)
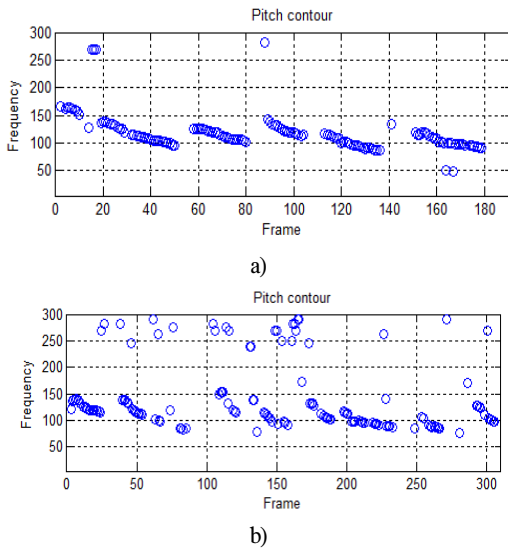
(Figure 3) Pitch contour of speeches

The following table shows the variance of the pitch with time. As the frame increases, the pitch dispersion changes. In particular, when compared with the distribution of voices of people who have defaulted and those who have not, It can be seen that the variance of the pitch is different. The change of the pitch dispersion with time is small, and the psychological state is stabilized, and the dispersion value decreases as we go to the second half of the telephone consultation. In the case of the pitch dispersion value of the person who caused the default, The variation of the dispersion value is large. The sudden change in the pitch dispersion value can be predicted to be a change in psychology. As shown in the graph in Fig. 3, although the change of the pitch is small, it is seen that the variable value is rapidly changed due to the psychological cause and repeated.

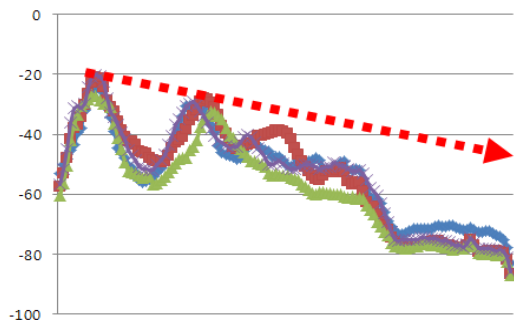(Table 1) Pitch variation of normal debtor

Frame	1	2	3	4	5	6
Variance	159	168	155	145	109	142
Frame	7	8	9	10	11	12
Variance	151	166	150	74	45	11

(Table 2) Pitch variation of default occurred

Frame	1	2	3	4	5	6
Variance	104	132	17	77	132	95
Frame	7	8	9	10	11	12
Variance	128	115	28	161	126	124
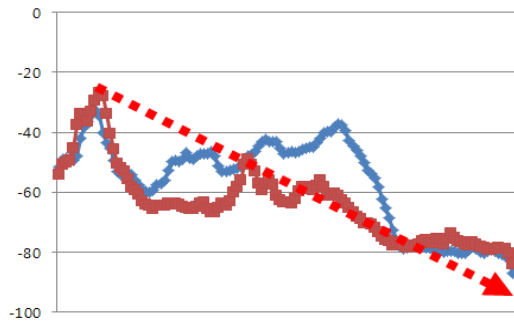
(Figure 4) Formant and formant slope of normal

(Figure 5) Formant and formant slope of default

The other independent parameter used is the formant analysis of the speech interval. Formant is a vocal track parameter that produces a voice and is a resonance characteristic. It can also be said to be a characteristic that is produced when a sound is generated and through a vocal track. The physical characteristics and habits of the speaker

are revealed. Figure 4 and Figure 5 are average formant graphs that are measured by dividing by default (individual default) conditions. Figure 4 shows the analysis of the voice before the bankruptcy or bankruptcy. And Figure 5 shows the result of voice analysis after bankruptcy. In Figure 4 and Figure 5, the horizontal axis is the frequency and the vertical axis is the size. The big difference between the two graphs is that it is easy to see the slope of the first and second buds and the difference in the slope. To make it easier to identify, I added a trend line to the dotted line. We can confirm that the slope of the formant is gentle after the bankruptcy occurs and can be utilized as an independent parameter of the SVM.

And the third, the parameter used in the analysis is the speech rate. This parameter also differs according to the conditions of individual default. As a result of the analysis, the borrowers who have a willingness to repay and maintain a good condition have a characteristic that the rate of speech is kept constant. However, when there was less willingness to repay and default occurred, there was a change in the rate of speech. This confirms the third criterion of the discriminator.

4. Experiment and result

In order to obtain parameter for this study, we were allowed to use the telephone voice record files for research purposes, which is a loan borrower and counselor from Korean savings banks(S-Capital and m-bank). Then, the recorded voices were analyzed through the parameterization, and the results from the analysis were compared with the actual personal credit score to find the similarities between these two. The 30 voices from the telephone conversation, comprising 18 males and 12 females, were collected. The age group for the sample data is all in the 20s-40s. Then, the collected voices were sampled with 11 KHz and quantized to 16 bits per sample.

Figure 6 and Figure 7 shows the result of analysis of voice data according to credit change. That is the analysis results of the voices before and after the bankruptcy. The analysis is the result of the cepstrum analysis of the voice, the parameter for the resonance of the vocal track is confirmed in the low quefrency, and the information about

the fundamental frequency of the vocal cord in the high quefrency. In Figure 6, slick harmonic form is seen in the middle quefrency. However, Figure 7 shows that the structure is different from Fig. By using some of these parameters, the criterion of the credit checker can be made. In the cepstrum analysis of Figure 3, the pitch and pitch perturbation to be used as independent variables in Chapter 3 can be obtained by analyzing in high quefrency. And in low quefrency, we can get information about formant and formant slope. And using the combination of quefrency according to the change of time, we can obtain the speech rate.
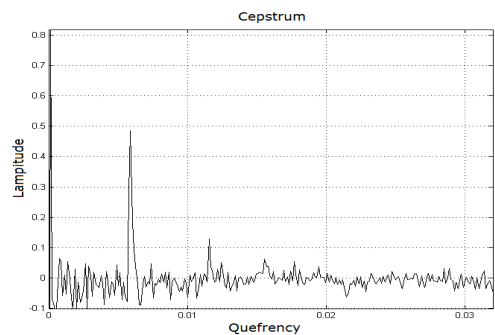
(Figure 6) Cepstrum analysis of normal voice
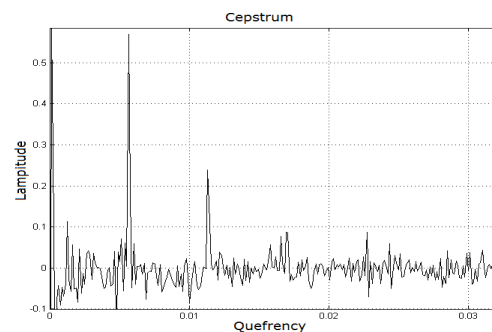
(Figure 7) Cepstrum analysis of default voice

When the SVM is performed by using the standard that uses the parameters simultaneously, the reliability of the result becomes higher as the data increases.

(Table 3) Some data for SVM learning

ID	x1	x2	x3	x4	x5	Y
1	132	306	0.61	3.21	766.71	Normal
2	151	209	0.345	3.22	477.28	Normal
3	164	1867	0.345	3.67	444.93	Default
4	172	1772	0.345	3.89	631.43	Default
5	201	1892	0.345	3.94	412.78	Default
6	210	1675	0.345	3.88	380.08	Default
7	142	525	0.295	3.33	350.33	Normal
8	138	420	0.24	3.32	7013.5	Normal
9	148	1839	0.24	3.33	8618.8	Default
10	110	1783	0.24	3.01	44.75	Default
11	89	325	0.023	3.1	5121.7	Normal
12	107	297	0.1	3.19	637.03	Normal
13	119	987	0.1	3.16	654.52	Default
14	132	1624	0.1	3.22	593.06	Default
15	131	682	0.095	3.37	463.39	Normal
16	145	418	0.075	2.99	486.07	Normal
17	230	1129	0.075	3.78	412.19	Default
18	227	1459	0.075	4.03	470.15	Default
19	209	1872	0.075	3.69	365.56	Default
20	208	1729	0.075	3.72	39.96	Default

(Table 4)　Variable table

Independent variable	X1	Pitch
	X2	Pitch　perturbation (variance)
	X3	Formant slope
	X4	Speech rate
	X5	Speech rate　jitter
Dependent	Y	Default detection

The independent variables for SVM are defined as shown in Table 4 below. The values of X1 to X5 based on the default are shown in Table 3. We have summarized the most visible data to be classified. The Y values in Table 3 indicate the actual default state and the normal state. The values extracted from the telephone consultation voices from X1 to X5 were written down. We use five independent variables to learn SVM, and we can construct a classifier based on this.

5. Conclusion and Further Research Work

Voices are an important factor in information delivery. In addition to linguistic information, this voice also contains various information such as emotional, health, and reliability. The voice is the time varying signal that changes various parameters over the time. The change of voice is one of the habits learned and used for a long time. The change depends on a language. But typically varies from three to four times per second. Which means, the vocal track parameters and excitation source change. In the meantime, IT development has made a lot of efforts to understand the linguistic information contained in people's words. In the development of that has done a lot of research to find basic characteristics and to find different characteristics of people and to signify their meanings. There are many ways to recognize patterns and utilize artificial intelligence.

In this study, we introduced a classifier that can be used to evaluate individual 's credit by analyzing voices other than linguistic information. This discriminant algorithm makes it possible to estimate the default or normal state of voices analyzed by binary decision logic. We examined the characteristics of each individual's voice and figured out the parameters of the reliable voice. In short, the reliable voice has a broader range of harmonics of a pitch, clearer pronunciation, more definite formant structure o unvoiced section. These parameters can then be used to build a determinant that evaluates reliability. Voice analysis parameters can be extracted through cepstrum analysis and the parameters generated here can be used to improve machine performance through machine learning. In this study, we used actual voice data of people who had changed credit status, though few in number, and we performed a part to compare features. In the future, we will do more research to improve performance, make judgments, and save time using more data related to credit in the future.

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