Study of Engine Oil Replacement Time Estimate Method using Fuzzy and Neural Network Algorithm in Ubiquitous Environment

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Abstract

To improve these unscientific methods, I would like to design a system that automatically tells replacement time of engine oil by fuzzy algorithm. There are 'time series analysis' and 'cause and effect' analysis in quantitative method. Time series analysis is to forecast the value by choosing one variable with the basis of historical data. All methods of demanding forecasting belong to time series analysis. Cause and effect analysis is the method, which makes a model by the relation between past values of other variables and the particular variable when the variable is influenced by other variables.

In the thesis to replace engine oil in optimum time and to be aware of right replacement time of engine oil automatically.

Keywords*: ubiquitous, neural network, fuzzy algorithm*

1. Introduction

No machine functions well without engine oil. Car engine needs proper amount of engine oil because of its spinning speed and power in ubiquitous environment. It is true that most of car parts needs oil. However it is never enough to emphasize the importance of engine oil.

Ordinary drivers are not aware of replacement time of engine oil. Even when we go to service center, they ask our latest replacement time if engine and distance covered since then. Or to see how much engine oil is consumed, they rely on extremely abstract methods such as using engine oil stick or viscosity of oil.

To improve these unscientific methods, I would like to design a system that automatically tells replacement time of engine oil by fuzzy algorithm. Function of engine oil is to smoothen contacted parts between metals of engine bearing part. This is called lubrication effect of engine oil but there are more functions of engine oil. The representative example is the cooling effect. Even though cooling devices like radiator prevent overheating of engine, engine oil as it circulates inside of engine falls its temperature and at the same time cleans its inside. This is called purity effect. Also engine oil has airtight effect. It fills the gap in piston or cylinder so the gas compounds or waste gas in cylinder won't go inside of engine. And the oil adhered to the metal inside of engine prevents the deterioration of metal when they touch each other. This is called shock-absolving effect. Engine oil gathers on the oil pan that is

[1]

lower part of engine and from there it circulates inside of engine by oil pump. There's metal filter called oil strainer where the oil goes up from oil pan and that eliminates the big substance. In the middle there's oil filter, which eliminates small substance and the oil that reaches at the end, falls back to oil pan.

In the thesis to replace engine oil in optimum time and to be aware of right replacement time of engine oil automatically, in Chapter 2, I would like to introduce old method of forecasting replacement time of engine oil. Also in Chapter 3, I will introduce forecasting of replacement of engine oil using neural net and Chapter 4 is about algorithm of engine oil replacement.

2. Examination of Condition of Engine Oil

Temperature of engine oil goes up when the vehicle is running and it goes down to the temperature of the air when the vehicle is parked. So every time the temperature changes, the quality of engine oil gets worse. Even when it touches the air, the oil gets oxidized and the condition of engine oil gets deteriorated. Of course, by friction of metals the condition goes bad. Also when the oil is used for a long period, substances like metal dust or sludge gets into oil and it makes the airtight effect and lubrication effect of engine oil debased. When engine oil is insufficient or debased the biggest problem is that the engine gets burnt. This is because the engine is not lubricated enough so the metals stick together. In this case, the repairing fee is very expensive. It is very dangerous when the car stops suddenly without any notice.

Only when the engine oil is black is not the right time to replace the engine oil so the viscosity of oil has to be checked as well. When the color is black and the viscosity is high, it means that it is time to replace engine oil immediately. Engine oil is consumed a little inside of engine. However if it gets too serious and makes white smoke, it is necessary to find out the cause and fix.

To forecast the replacement time of engine oil comparatively, history data such as viscosity of the vehicle that replaced engine oil, distance traveled, vehicles for long or shout range etc. is needed. The method is forming a model, which tells the tendency of the vehicle. So by using this, one can tell the future. Once again, if present time is t, by using historical data, one can foretell the future (t+l). There are two ways of forecasting future. One is qualitative method and the other one is quantitative method. Qualitative method is used when there's no historical data or when it is not possible to make a model. So it is depended on the knowledge and opinion of experts and Delphi is one of the well-known methods.

There are 'time series analysis' and 'cause and effect' analysis in quantitative method. Time series analysis is to forecast the value by choosing one variable with the basis of historical data.

All methods of demanding forecasting belong to time series analysis. Cause and effect analysis is the method, which makes a model by the relation between past values of other variables and the particular variable when the variable is influenced by other variables. From that, one can forecast the future value of certain variable. However it is very difficult to clarify the relationship and analysis of other variable.

time series method
y(n) = a + b * x(단, y(n) = n Prediction Value) a = ∑ y/n - b * ∑ x/n b = {n * ∑ xy - (∑x) * (∑y)} / {n * ∑x² - (∑x)²} x = Prediction year n : number of data
Moving average method
y(n) = {x(n-t) +x(n-t+1) + ... +x(n-1)} / t Cf) Prediction Value of y(n) : n x(n-t) : Real Value of (n-t) t : Prediction time
Weighted average
y(n) = {a1 ∧ x(n-t) +a2 ∧ x(n-t+1) + ... +at ∧ x(n-1)} Cf) Prediction Value of y(n) : n x(n-t) : Real Value of (n-t) t : Prediction time a1 : weight of n-t (∑a = 1) t : Prediction term
Exponential smoothing
y(n) = a * x(n-1) + (1-a) * y(n-1) 단, y(n) : x(n)(Prediction Value of n) : a(Real Value of n) : 평활계수

Figure 1. Estimate model about engine oil replacement time

3. Forecasting the replacement time of engine oil by using neural net

The process of demanding forecasting is as below and on it means time on X-axis and value of variable on Y-axis.

$$Y = \beta\sigma + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + . \quad . \quad . \quad + \varepsilon \quad (1)$$

/

But, right replacement time of engine oil

: Fact 1 affecting dependent variable.
: Fact 2 affecting dependent variable.
: Fact 3 affecting dependent variable.
⋮
: Fact 10 affecting dependent variable.

The following shows about neural network algorithm discussed in this thesis.

① Initialize offsets and weight.

② Indicate input and target on the neural network.

③ getting errors and deltas of output neurons, transmit inversely to concealed layer

$$ej = tj - aj \quad .$$
$$\delta j = aj (1 - aj) ej$$

④ From the delta transmitted inversely, get the errors and deltas of the neurons in the concealed layer and transmit it in reverse.

$$ej = \sum_{k} wjk\ \delta k$$

$$\delta j = aj\ (\ 1 - aj\ )ej$$

⑤ Adjust the connected weight according to delta rules.

$$W(new)ij = W(old)ij + \alpha\delta iaj + \beta\Delta wij(old)$$

$$bias(new)ij = bias(old)ij + \alpha\delta.\ 1 + \beta\Delta biasij(old)$$

⑥ Repeat the 1-5 process on all the input pattern

⑦ Repeat the process 4 until the neural network is completely learnt

Table 1. Input data for engine oil replacement time estimate which use neural network

Input condition	Engine oil replacement time	Engine oil replacement time
1. The amount of engine oil in the past 12 months.	Small	Big
2. The viscosity of engine oil in the past 12 months.	Small	Big
3. The driving distance in the past 12 months.	Big	Small
4. The road conditions in the past 12 months.	Big	Small
5. The habit of abrupt departure and braking.	Small	Big

<Table 1> shows the process of forecasting when 5 different conditions are input. It is very important to set initial value of neural net. By setting adequate initial value, there will be less learning error and the learning process will be shorten. Generally learning of neural net starts with certain initial value. Also learning ability and error is depended on what is chosen as a seed value.

Also, The learning rate can either be convergent having less learning error or be led to the saturation point, depending on what initial value you choose. As the result, it is crucial to minimize the error and make the learning process be convergent rapidly by selecting right initial value in the data you want to analyse.

Therefore, even though it is limited, I have had an experiment according to the range 0.1,0.3,0.5, 0.7 and 0.9 only with (kappa, theta. phi, mu) concerning every situation.

① Let it learn the different 10 situation tests using neural net.

② After predicating the 10 test data, calculate the error between test data and the predicated data.

: test data

. : predicated value

(1)

the gap between 시점 시계열 and the prediction

(2)

Here, ( ) means the(st) unprecedented(particular???) value that is modified value from the identified test data,( ).

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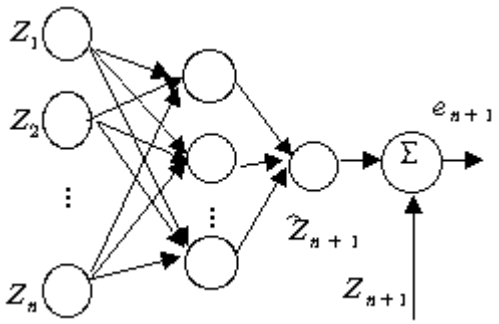


Figure 2. Engine oil replacement time estimate model that use neural net

Neural network prediction							Efficiency of engine oil replacement rime(%)	
Driving distance regular: 5000KM	Abrupt departure and braking condition	The amount of engine oil	Viscosity of engine oil	Cars driving various roads	Riving long distance	Road condition	Intelligence form	Existing form
BIG	BIG	BIG	BIG	SMALL	SMALL	SMALL	**88**	**75**
BIG	SMALL	SMALL	SMALL	BIG	BIG	BIG	**82**	**60**
BIG	SMALL	SMALL	SMALL	SMALL	SMALL	SMALL	**88**	**65**
SMALL	SMALL	SMALL	SMALL	SMALL	SMALL	SMALL	**85**	**77**
BIG	medium	medium	medium	medium	medium	medium	**91**	**84**
SMALL	SMALL	medium	SMALL	SMALL	SMALL	SMALL	**87**	**83**
SMALL	SMALL	BIG	medium	BIG	medium	BIG	**82**	**75**
SMALL	BIG	SMALL	medium	BIG	BIG	BIG	**90**	**73**
SMALL	BIG	medium	BIG	SMALL	medium	BIG	**79**	**67**

<Table 2> is the result of practice of neural net algorithm and it forecasts the replacement time of engine oil.

4. Fuzzy algorithm for replacement of engine oil

Generally fuzzy relation is fuzzificated concept of relationship in mathematics. For example, such relation like ‘X is very similar to Y’ or ‘X is more active than Y’ is fuzzy relation. Fuzzy relation is very important method to express fuzzy conditional sentences in fuzzy inference.

When cartesian product of Set X and Y is X x Y, a subset of X x Y, R, is called ‘relation’. When (X,Y) becomes elements of R, X and Y has relation. If _____, x and y has no relation. If relation R is fuzzy set, R is fuzzy relation from X to Y. At this point, level of relation of X,Y is shown as position function ____. As relation is generally shown by graphs and determinants, fuzzy relation can be shown by fuzzy graphs and fuzzy determinants as well. Fuzzy graph is expressed by using vertex and arc, and here arc means intensity of relation. Sometimes it does not end with fuzzification of arc but it can substitute vertex set with fuzzy set, not ordinary set.

Table 5. Fuzzy rule that consider condition of road

Step of quantization	the mileage of a car
-6	X <=-90 Centi Meters
-5	-90<x<=-60
-4	-60<x<=-40
-3	-40<x<=-20
-2	-20<x<=-10
-1	-10<x<=0
0	0<x<=10
+1	10<x<=20
+2	20<x<=30
+3	30<x<=40
+4	40<x<=50
+5	50<x<=60
+6	x<60 Centi kilo meters

	NB	NM	NS	Z	PS	PM	PB
NS	NS	NS	NB	NB	NB	NS	NB
NM				NM	NM		
NS			NM	NS			
Z		NS	NS	Z	PS		
PS			PS	PS	PM		
PM			PM	PM			
PB	PS	PM	PB	PB	PB	PM	PM

In <Picture 3> if traveled distance of drivers a, b, c, d is 4000-5000 Km (long distance), it is marked as 0.8-1.0. Also if their distance is 2000-3000 Km, it is marked as 0.4-0.7. However if the distance is less than 2000 Km, it is marked as 0.1-0.3.

P1, P2, P3 is showing the replacement time of engine oil according to the traveled distance. The numbers that is marked on the extension line, are when the driver had quick start or ran on unpaved road so it produced heat.

Therefore it explains that even with the same traveled distance, if the driver has good driving habit, it will delay the replacement time of engine oil. On the contrary, if the driver has bad driving habit and ran on unpaved road, it is necessary to replace the engine oil sooner.

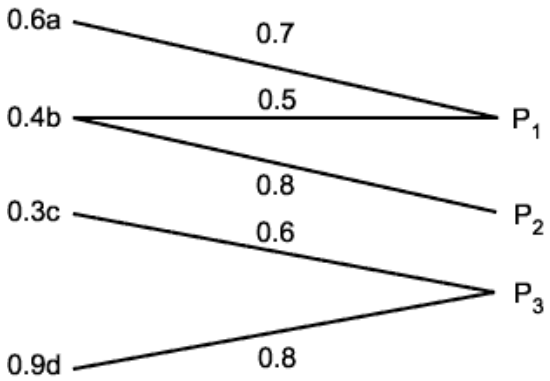


Figure 3. Engine oil replacement time that use Fuzzy rule

(RULE 1) IF DPSV IS PB
AND USPC IS PB
THEN OPRG IS BIG
(RULE 2) IF DPSV IS PB
AND USPC IS NS
THEN OPRG IS MEDIUM
(RULE 3) IF DPSV IS NS
AND USPC IS NS
THEN OPRG IS SMALL

here,

DPSV : the driving distance of car

USPC : road condition (long distance/ short distance)

driver condition (abrupt departure exsistence:non-exsistence)

the amount of error variation.

OPRG : engine oil replacement time (10 levels)

The following is explaining the yielding process of engine oil replacement time with using Fuzzy controling rules.

(Rule 1)

[0.3/4, 0.5/5, 1/6] ^ [0.7/-3, 0.6/-2, 0.8/-1, 0.4/0, 0.1/1]
↑ ↑
^ [0.3/4, 0.5/5, 1/6]
= 0.3 ^ 0.7^ [0.3/4, 0.5/5, 1/6]
= [0.3/4, 0.3/5, 0.3/6]

(Rule 2)

[0.3/4, 0.5/5, 1/6] | ^ [0.3/-6, 0.2/-5, 0.8/-4, 0.5/-3,
↑ ↑
0.4/-2, 0.2/-1] | ^ [0.1/2,0.5/3,1.0/5,0.5/5,0.2/6]

= 0.3 ^0.5^[0.1/2, 0.5/3, 1.0/4, 0.5/5, 0.2/6]

= 0.1/2, 0.3/3, 0.3/5, 0.3/5, 0.2/6

(Rule 3)

[0.3/1, 0.9/2, 0.7/3, 0.3/4] | ^ [0.7/-3, 0.6/-2, 0.8/-1, 0.4/0, ↑ ↑

0.1/1] | ^ [0.3/1, 0.9/2, 0.7/3, 0.3/4]

= 0.3, 07^[0.3/1, 0.9/2, 0.7/3, 0.3/4]

= 0.3/1, 0.3/2, 0.3/3, 0.3/4

The steps of non-Fuzzification:

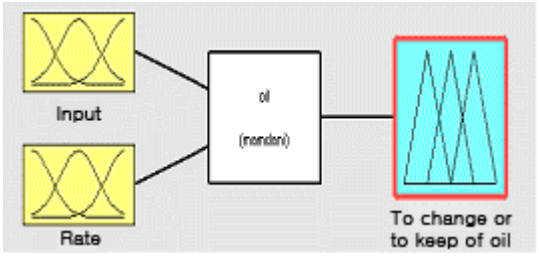
u'=[0.3/1, 0.3/2, 0.3/3, 0.3/4, 0.3/5,0.2/6]

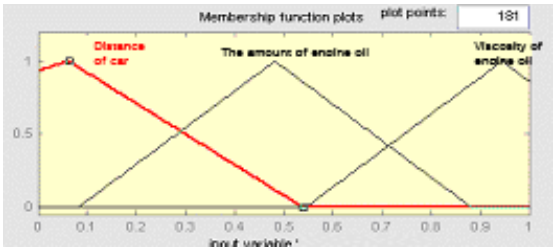
{0.3 *[1+2+3+4+5] }+0.2*[6] } / (0.3 * 5) + (0.2*1)

= 3.35

Therefore the level of replacement time is 3 out of 10 that is less than the pollution level.

In <Picture 4> according to the viscosity of engine oil, it explains the rule to forecast the replacement of engine oil. If fuzzy neural net algorithm that is proposed in this thesis is applied, forecasting of accurate price is possible and will maximize the profit of people in agricultural field.





(input value == Viscosity of engine oil) & Degree==G) => (Replace or keep=yet)(1)
(input value == Viscosity of engine oil) & Degree==M) => (Replace or keep=yet)(1)
(input value == Viscosity of engine oil) & Degree==S) => (Replace or keep=Now)(1
(input value == amount of engine oil) & Degree==G) => (Replace or keep=yet)(1)
(input value == Amount of engine oil) & Degree==M) => (Replace or keep=yet)(1)
(input value == Amount of engine oil) & Degree==S) => (Replace or keep=Now)(1)
(input value == Distance of car) & Degree==G) => (Replace or keep=Yet)(1)
(input value == Distance of car) & Degree==M) => (Replace or keep=Yet)(1)
(input value == Distance of car) & Degree==S) => (Replace or keep=Now)(1)

Figure 4. Whether or not gasoline replace that use fuzzy rule

<Table2> Refers to the predicated result chart of engine oil replacement carried out from the neural network algorithm.

Table 2. The comparison of predicated efficiency of engine oil replacement time

Neural network prediction							Efficiency of engine oil replacement rime(%)	
Driving distance regular: 5000KM	Abrupt departure and braking condition	The amount of engine oil	Viscosity of engine oil	Cars driving various roads	Riving long distance	Road condition	Intelligence form	Existing form
BIG	BIG	BIG	BIG	SMALL	SMALL	SMALL	**88**	**75**
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SMALL	BIG	medium	BIG	SMALL	medium	BIG	**79**	**67**

5. Conclusion

Korea is the leading country in IT field and motor industry. However sharp curve road, sleeping driving, fog area, freezing point is announced at the right time, the number of traffic accident will be decreased a lot. This thesis explains the heat sensor to forecast the right replacement time of engine oil. Also this proposed fuzzy rule and fuzzy system that decide replacement time of engine. Everybody tell the importance of engine oil but all have different opinions about its replacement time. Some says every 5000 Km and some says every 10,000 Km or some says ever 20,000 Km. It is not easy to tell which is right because if differs from kinds of vehicles and driving habit. Generally it is known that it is good to replace engine oil twice a year.

Because it differs from ever vehicle, it is good to check the replacement time of engine oil by oneself. If the engine oil is not replaced at the right time, it will cause the braking of engine. Forecasting of replacement time of engine oil is possible with neural net algorithm. For the results of the test, by using neural net and fuzzy method made 25% of increase of life of engine oil.

Engine oil is one of the essential parts to run the vehicle smoothly. But not many drivers make record of their engine oil period so it is not easy to tell when to replace their engine oil. Also even the driver replaces the engine oil regularly, if the vehicle runs long distance, it will cause the leak of engine oil. Therefore using fuzzy algorithm will tell the right time to replace the engine oil automatically and it is good for the vehicles and drivers as well.

Proposed system is good and effective. Also it prevents the pollution and disorder of engine. To solve these problems, suppose all vehicle has rfid tag which has identification, blood type, contact and registered number, I would like to suggest a safety system that automatically reads the rfid tag automatically when car accident occurs. By 900 Mhz rfid tag that is produced by Kiss Com can give call to nearest hospital automatically by reading rfid tag. Process is as below.

1. Attach RFID TAG
2. Decide either severe injury or slight injury.
3. Decide the cars including severely injured patient through the Reader.
4. Generate RFID antena wave and transmit and receive Return signals from TAG.
5. Recognize the distinguished number ID received from tag to antena, and control the wave.
6. Draw out the blood type information and drivers' ID information at the TAG.
7. Deliver the information data of the driver who drove the vehicle which had the accident to the traffic controlling system
8. Communication with broadband KT communication network
9. Automatic phone calls to police and hospitals
10. If the 3-minute operation of reader is failure, automatically call emergency police

Figure 8. recognition of license number using RFID tag

Figure 9. RFID TAG And READER

Figure 8 is explaining the license number recognition process by using RFID tad, and Figure 9 is showing **900M Hz RFID TAG and READER used in this thesis.**

(1) GET EPC
. Not to appoint an antenna, continual EPC read
Transmission of a message -> GE00000A<cr>
Receipt of a message ->
EF040309123456ABABCEF00011111111<cr><lf>
02 P<cr><lf>
03 P<cr><lf>
04 P<cr><lf>

(2) GET DATA
. Not to appoint an antenna, continual User Read Memory Data
User Memory Start Address : 0x18, the number of User Memory : 8
"12345678" was saved In User Memroy (HEX : 3132333435363738)
. Transmission of a message -> GT00000AN1808<cr>
. Receipt of a message ->
01 3132333435363738<cr><lf>
01 P<cr><lf>
02 P<cr><lf>
03 P<cr><lf>
04 P<cr><lf>

Figure 10. Transmitted-received message

```
# include <stdio.h>
# include <stdlib.h>
# include "onescnt.h"
# define NULL 0
# define true 1
# define false 0
void main (int argc, char *argv[ ])
{
int i, j, k, message[40], num_bits, bitcount, bytecount, crc, next_bit, crc_temp, message_temp;
int maskreg[8] = {1, 2, 4, 8, 16, 32, 64, 128};
int crc_nibble[4];
char ch
FILE *fin;
if (argc != 2)
{ printf ("proper usage is CCITT {indata file with data in hex}\n"); abort (); }
if ( (fin =fopen(argv[1], "r")) ==NULL)
{printf("Can't open %s\n", argv[1]; abort();}
i = 0;
while ( (ch=fgetc(fin)) !=EOF)
{
message_temp = 0;
//retrieve the input data field and convert to an integer message field
if ((ch >= 'a') && (ch <= 'f')) ch = ch - 0x20
if ((ch >= 'A') && (ch <= 'F')) ch = ch - 0x70
if ((ch >= '0') && (ch <= '?'))
{
message_temp = ch - '0';
message[i++] = message_temp;
}
}
// At this point, message[ ] holds data with nibbles (4 bits on each array). This will be used for
CRC calculation
message[ i ] = -1;
k = i
// The above is used for array checking and k value is the total number of nibbles.
printf ("Read in %d nibbles. \n", k);
printf ("Original data in hex read in from data file: \n");
for (i = 0; i < k; i++)
printf("%x ", message[ i ]);
printf("\n\n");
// Now computing the CRC of data
//----------- Initialization ----------------------------
crc = 0xffff; //initial CRC value
crc_poly = 0x8408; //1000-0100-0000-1000
//-------------------------------------------------------
printf ("Initial CRC value in hex: %x ... \n", crc);
num_bits = k*4;
for ( i = 0; i < num_bits; i++)
{
bitcount = i % 4;
bytecount = i/4;
next_bit = (message[bytecount] & maskreg[bitcount]); //This will find the next data bit to apply
next_bit = ((next_bit >> bitcount) & 1); //This will move the current data bit to LSB of next_bit
// and make all bits except LSB bit to zero
crc_temp = crc^next_bit; //xor the last nibble of crc (actually the last bit of CRC) with next_bit
if (crc_temp & 1)
{
printf ("xor = 1\n");
crc = crc >> 1; //Shift the crc by 1 to right
crc = crc^crc_poly ; //xor current crc with crc_poly

crc = crc|0x8000; //this may not be necessary
}
// if it is zero, just shift crc by 1
if (!(crc_temp &1))
{
printf ("xor = 0\n");
crc = crc >> 1;
crc = crc & 0x7fff;// this may not be necessary
}
printf("Temp CRC after iteration %d: ", i);
for (j = i; j<num_bits; j++)
printf(" ");
}
printf("%d\n", crc);
}
crc_nibble [0] = crc & x000f;
crc_nibble [1] = (crc & x000f >> 4;
```

```
crc_nibble [2] = (crc & x000f >> 8;
crc_nibble [3] = (crc & x000f >> 12;
printf("Bit order for shifting in nibbles in LSB first. \n");
printf ("\n CRC at end: %x ", crc);
printf ("Send %x %x %x %x \n", crc_nibble[0], crc_nibble[1],crc_nibble[2],crc_nibble[3],);
printf("\n\n");
fclose(fin);
}
```

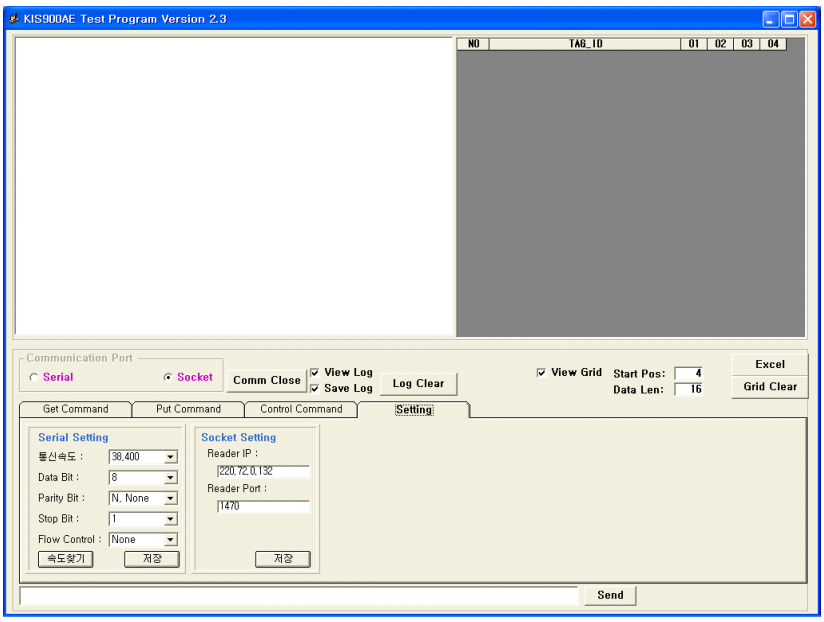

Figure 11. RFID TAG transmitted-received message

TEST screen

Car accident	Patient condition							**Identification** info			READER	
Intersection of 3 roads	Car speed		Height / CM			Blood type	weight KG	age	job	sex	success	failure
ABC	44	56	80	100	100	150	B	70	83	1	1	60sec	43sec
CDE	84	56	67	150	100	200	O	50	61	2	1	60sec	48sec
ABC	64	74	87	100	300	200	A	46	51	0	0	60sec	53sec
EFG	86	74	64	150	100	100	O	23	12	2	0	60sec	61sec
ABC	94	98	85	100	150	120	B	78	41	1	0	60sec	51sec
CDE	127	126	65	150	120	166	O	56	73	2	0	60sec	47sec
ABC	44	24	43	150	130	200	AB	55	41	2	0	60sec	57sec
CDE	46	66	65	100	170	200	A	67	88	1	1	60sec	51sec

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