

## An Efficient Tool for Digital Evidences in Uyghur, Kazakh, and Kyrgyz Information Processing

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**Abstract** — Analysis is one of the important steps of computer forensics. The most popular analyzing tools, such as EnCase and FTK, are suitable for processing information in English or in Chinese. If the original evidence is in other scripts such as Uyghur, Kazakh, Kyrgyz (hereafter: UKK), it will be much more difficult to identify, filter, and fulfill other kinds of analyzing. In this paper, the variety of UKK characters, the diversity of its encoding scheme and the particularity of the denotation for UKK in different documents are analyzed in detail. Then, it is designed and implemented the efficient tool for digital evidences in UKK according to the nature of UKK and its encoding situation. Finally, the convenience and efficiency of the system is proved by the many experiments and actual applications.

**Keywords** - Computer forensics; UKK; Digital evidence; EnCase

### I. INTRODUCTION

Computer security incidents and crimes are becoming increasingly serious all over the world and have become the focus of social concern. In those Computer-related crimes, computers may be the intruder, guilty tool or the storage tool of crime information. Therefore, a large number of digital evidences are left in computers and their peripherals [1, 2, 3]. Investigators must take digital evidences from computers or their peripherals and analyze the evidences carefully. In recent years, many kinds of computer forensics software tools have been developed, such as EnCase, FTK [4, 5] etc, so as to make the investigation for computer crimes easy. Most of these computer forensics tools have the basic function of matching the demanded binary sequences, and then help investigators to find new clues or evidences of the crime [6, 7]. However, there is an obvious problem with different encoding methods adopted by different countries and regions. This problem results in the differences of corresponding binary sequences on hard disk. What is more, even in the same country or region, words may have different binary sequences on the hard disk even they are displayed the same on the screen [8].

EnCase supports Unicode data decoding. It is unconcerned with the operating system or platform, computer program or language that the Unicode standard provides a unique encoding number for every character. EnCase can search and display any language character that Unicode support, and code pages that Unicode supports. This bring the convenience to the examiners that they have

the ability to search and view various data such as German, Arabic or Kanji in its native format [9]. It is known that Chinese are encoded by both Unicode and GB2312, so it is not easy to search or identify Chinese information by EnCase directly. In order to deal with this problem, some Chinese companies or research institutes have made some relevant auxiliary tools for EnCase (e.g. Xiamen Meiya's Partner of EnCase). Chinese investigators can use these tools to find simplified and traditional Chinese evidences easily. But there are many minorities in China, especially in some remote areas. Almost all of the minorities in China have their own languages. For example, there are three main ethnic minorities, Uyghur, Kazak, and Kyrgyz (abbreviated to UKK) in Xinjiang Uyghur Autonomous Region (hereafter: XUAR) of China, and most of the people speak in UKK [10]. At present, the development of the information processing system for UKK is relatively slow [10,11]. How to get digital evidences from the UKK system is still a serious problem for the investigators.

Obtaining UKK evidences from hard disk is more difficult than obtaining evidences in Chinese characters. In the late 90's, Microsoft Windows and object-oriented software development technologies enhanced the ability of computer system to deal with UKK information. Many colleges, universities, companies, and research institutes have launched various kinds of UKK information process systems. These systems make UKK information become digital and promote the social development of the XUAR region. However, the UKK encoding had not followed international or national encoding standards until 2008[12,

10]. There are still some confusions, for example, different UKK information process systems are not compatible and cannot share their resources with each other directly. Therefore, a unified encoding standard is very important for obtaining digital evidences in UKK from hard disks. The investigators in Xinjiang often need to extract UKK evidence from computer and related equipments. But UKK characters cannot be recognized correctly without the support of UKK information process system. The first and the most important reason why EnCase could not get and analyze UKK digital evidences directly and efficiently is the particularity of UKK characters. The second reason is the complexity of processing UKK information, and the third is the various types of electronic documents in UKK.

In this paper, it is discussed the reasons why there are many difficulties when using EnCase in a UKK system. Then an effective solutions are presented to solve these problems. We designed and implemented an efficient tool to deal with UKK digital evidences. The system indicates its convenience and efficiency in practical application.

The remaining of this paper is organized as follows: section two is focused on analysis of the diversity of UKK encoding system, the direct input and output problems of UKK keyword in EnCase, and particularity of structures of UKK Web documents; section three covers the topics such as function of each model and the implementation of our developed system; section four gives details of the experiment study in order to show how to use our tool by citing an example and showing main interface of the tool. The conclusion is given in section five.

## II. THE LIMITATIONS OF ENCASE IN UKK INFORMATION

### A. *The Diversity of Encoding*

There are different kinds of UKK scripts in different regions. At present, UKK people mainly live XUAR in China, Central Asia, West Asia and some Western countries. The UKK people in the different regions use different scripts for various reasons. The Uyghur (Kazak or Kyrgyz) people living in China uses Arabic Script based Uyghur (Kazak or Kyrgyz), the UKK people living in Central Asia use Cyrillic and the others use Latin based on Uyghur [13]. Because the scripts like Cyrillic and Latin of UKK belong to alphabetic writing system, there is no problem when doing sequences matching with certain information. But the UKK in China use Arabic letter based UKK scripts which borrow some Arabic and Persian letters and belong to alphabetic writing system, which is composed of 32 alphabets and has more than 120 characters [13,14].

UKK is written from right to left direction which is opposite to Chinese and Western writing practices [13,14]. Each letter of UKK has four or two different writing types: initial form with only the tail of a letter connecting with the next one; intermediate form with head and tail both

connecting with the adjacent letters; final form is written with head connecting with its last one, and isolated form is written with neither of head or tail connecting with their adjacent ones. Choosing a specific type of the character relates to its adjacent ones in order to show UKK characters correctly. Therefore, when displaying the UKK character strings on the computer screen, the computer system needs to convert one shape of a character to other ones frequently. The method realizing the process by the computer automatically is called automatic selection.

Character can only be processed by computer after encoding. The default encoding method is its internal code. ASCII is used to encode for processing western character in early time. While researchers of Chinese character information processing are following GB2312 for simplified Chinese and Big5 for complex Chinese.

The kernel of Windows NT/2000/XP and the API function that relates to text output of Windows9X all support Unicode. Microsoft has added Arabic character supporting at these platforms. Because the majority of UKK character shapes are very similar to Arabic characters, some enterprises and scientific research institutes turn to intrinsic code of Arabic character set to realize the processing of UKK scripts. From the start of research on UKK information processing on Windows platform, aiming at different applications, each enterprise and scientific research institute has adopted multi-coding scheme to UKK character set. This article summarizes some commonly used types of coding schemes as follows after the analysis of more than 30 UKK information processing systems that have been known.

Forensic tools realize information search function with the help of character string looking up a great deal of information. This also means that if a user enters UKK information based on Unicode coding scheme, the forensic tools would search the evidences using Unicode coding scheme. So in order to enlarge the searching of UKK evidences, forensic requests can't be put in until the UKK information in one coding scheme is transformed into UKK information in all the other kinds of coding schemes. At the same time, two problems should be given more attention. First, although there are four kinds of commonly used coding schemes mentioned above, different UKK system developers' coding schemes have quite different code definitions for the UKK letters. The TableI shows the different codes of the same UKK Letters (part of the 120 characters) in different UKK systems.

TABLE I THE DIFFERENT CODES OF UKK LETTERS IN DIFFERENT SYSTEMS

No	Letter	System 1	System 2	System 3	System 4	System 5
1	ا	0x686	0x67E	0x625	0x626	0x686
2	ب	0x698	0x686	0x626	0x629	0x698
3	ت	0x6AD	0x698	0x629	0x62B	0x6AD
4	ث	0x6AF	0x6AD	0x62B	0x62D	0x6AF
5	ج	0x6BE	0x6AF	0x62D	0x630	0x647
6	چ	0x6D5	0x6D0	0x647	0x649	0x6D5
7	ح	0x641	0x641	0x641	0x641	0x6A7

In the Table I, same UKK characters are coded different symbols, for example, for the letter “ا” it is used 0x686 in System1 and 0x67E in System 2. And this increases the complexity of the final search of character string. Because the character set and code storage method supported by different operation systems and application software is different, and some system have used basic area code (0x6XX) to store information based on UKK code while others have used extended area code (0xFEXX).

*B. Input of UKK Words Cannot Work With Computer Forensics Software*

When a computer forensics software (such as EnCase) is used, and the original information is expressed in UKK, it is became a very difficult job how to input UKK words and let these words be converted to the corresponding binary sequences. There are three reasons: firstly, the UKK input methods cannot work with computer forensics software directly; secondly, even they can work together, the software cannot convert the inputted words into the corresponding binary sequences automatically; finally, during the survey, the investigators cannot get all the input methods of UKK at the same time.

*C. Matched Binary Sequences Cannot Be Reversed To The Corresponding UKK Characters*

It is a pity that even if the investigators know all the encoding schemes, and get the right binary sequences for the keyword, and all the sequences are well matched on the hard disks, there is still an thorny problem existing, that is, it is impossible to convert the chosen binary sequences into

UKK words.

*D. Particularity of UKK Web Documents*

In the majority of documents, the UKK information is stored as Chinese and English information. However, different UKK processing systems, based on different encoding schemes, adopt different ways to denote Web documents. Because there are so many systems to process UKK information, many schemes are different.

When the processing system adopts the first or second encoding scheme, the encoding is single-byte code encoding. In these systems the Web page code in HTML documents directly store characters’ encoding and profile information. In order to display the UKK information correctly, web designers embed the profile information in the Web. In this way, users can browse the information in their browsers.

Based on the use of the third and the fourth encoding scheme (hereinafter referred to Unicode encoding) UKK text information processing systems adopt particular storage structure. In detail, when the web design software use the character set utf-8 (marked in the source Charest = utf-8) to do the static Website, the HTML source code of the website contains the basic areas Unicode Encoding (0x621 - 0x6d5) of the UKK information. So if the website is opened by a Notepad, it will show the UKK information. If a website is designed by using GB2312 or ISO-8350, or it is updated according to the database, the UKK information will be denoted by encoding in extended area. When this kind of website is opened by a Notepad, it will be seen as “&#” and Unicode of the UKK letter in decimal.

Different kinds of application software are used different encoding schemes in designing and realization. The more encoding type investigators know, the more efficiently the forensic tools work. There are so many different kinds of software with various encoding types developed and being used in XUAR. So EnCase cannot work efficiently without involving various encoded keywords in UKK information. If the character-set of the Web developing tools is not utf-8 (Unicode, Arabic 1256, Base 64, Q\_P, RTF, WEB special characters) the matching is not efficiently. The following table II shows the different codes of the same Uyghur word “سالام” (Hello) in different Web documents.

TABLE II THE DIFFERENT CODES OF THE A UYGHUR WORD “سالام” (HELLO) IN DIFFERENT WEB DOCUMENTS

Web encoding	codes in basic area for the word “سالام”	codes in extend area for the word “سالام”
Unicode	33 06 27 06 44 06 27 06 45 06	B3 FE 8E FE FB FE E1 FE 20 00
UTF-8	D8 B3 D8 A7 D9 84 D8 A7 D9 85	EF BA B3 EF BA 8E EF BB BB EF BB A1 20
Arabic1256	D3 C7 E1 C7 E3	BA C3
Base64	2LPYp9mE2KfZhSA=	77qz77qO77u777uh
Q_P	=D8=B3=D8=A7=D9=84=D8=A7=D9=85	=EF=BA=B3=EF=BA=8E=EF=BB=BB=EF=BB=A1
RTF	\D3\C7\E1\C7\E3	'D3\C7\E1\C7\E3\
Special symbols in the web pages	&#1587;&#1575;&#1604;&#1575;&#1605;	&#65203;&#65166;&#65275;&#65249;&#32;&#32;

It is indicated clearly from the Table II that, the codes are different if different kinds of encoding schemes are used for same UKK words. It will much more different if a UKK sentences, paragraph or whole document is concerned. So it is very important to transform together in analyzing UKK codes.

Meanwhile, there are different kinds of encoding schemes are used in UKK websites in XUAR. For instance, there are two Html codes as follows to explain the two kinds of UKK webs using different html codes for the same information as ( شىنجاڭ ساغچى ئوفىستىرلىرى ئالى تېخنىكومى ) in the browser, and its character set is Microsoft UKK set that provided by Microsoft Corporation. The first kinds of codes are as below:

```
<HTML>
<HEAD>
<TITLE>The first kind of UKK
website</TITLE>
<BODY>
<META http-equiv=Content-Type content
="text/html; Charest=utf-8">
<FONT face="Microsoft Uighur" >
شىنجاڭ ساغچى ئوفىستىرلىرى ئالى تېخنىكومى
</FONT>
</BODY>
```

The second kinds of Html codes are indicated in the following box:

```
<html>
<head>
<title>The second kind of UKK website</title>
</head>
<body>
<meta http-equiv=Content-Type content
="text/html; Charest=gb2312">
<span lang=AR-BH dir=RTL style='font-size:
12.0pt; font-family: "Microsoft Uighur">
&#1588;&#1609;&#1606;&#1580;&#1575;&#1
709;&#32;&#1587;&#1575;&#1602;&#1670;&
#1609;&#32;&#1574;&#1608;&#1703;&#1703;
&#1609;&#1587;&#1578;&#1609;&#1585;&#1
604;&#1609;&#1585;&#1609;&#32;&#1574;&
#1575;&#1604;&#1609;&#32;&#1578;&#1744;
&#1582;&#1606;&#1609;&#1603;&#1608;&#1
605;&#1609; </span></p>
</body>
</html>
```

It is clear from the two examples that, UKK information is much more complex and different if they are implemented with different kinds of encoding schemes, and it is difficult to process with computer forensics software's.

### III. DESIGNING AND IMPLEMENTATION OF THE SYSTEM

#### A. Design of the system

Considering the variety of UKK, diversity of encoding and particularity of representations for UKK words, we designed the multi-direction conversion system of UKK encoding as showing in Figure 1.

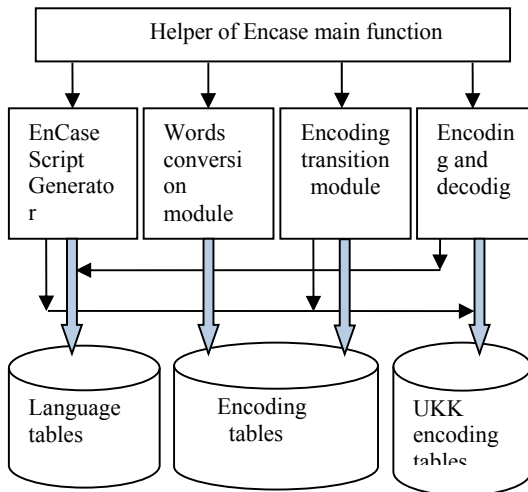


Fig.1 The Structure of our Assistant Tool

It is clear from the Figure 1 is that the system includes 4 main parts: EnCase Script Generator for UKK, Words conversion module, Encoding transition module and Encoding and decoding module. Words conversion module can convert words among the three kinds of scripts that UKK use. Encoding conversion module responsible for converting one encoding sequences in certain UKK information system into other many encoding sequences in respective UKK information system.

(i) Encoding and decoding module. It can encode and decode the UKK keywords for EnCase when it is stored or represented.

(ii) EnCase Script generating module. This module can generate EnCase script code file including all kinds of encoding types for given keywords in UKK.

(iii) EnCase Scripts Creator for UKK model. This EnCase scripts creator develops the EnCase script codes for UKK keywords entered by investigator to find more evidences in the target storage media.

#### B. System Implementation

For the differences of scripts in different regions and the diversity of encoding, and in order to achieve computer forensics of documents in UKK (concerning kinds of words, encoding scheme, bytes of the code, and their storage direction, etc.), some pretreatment is made as the following.

##### 1) Classification of characters and their encoding

Generally speaking, the UKK information related to crimes on the computers is often adopted in a certain kind or some kinds of code schemes. To western letters, the classification is relatively simple, that is, the classification is decided by the encoding range of Latin and Cyrillic characters. To UKK letters, using the computers to classify is a more reliable method. In detail, the encoding schemes in Table I have different encoding ranges, so we can classify the characters by its encoding values.

##### 2) Conversion of direction

In Table I, key words encoded by Single-byte basic area scheme are stored from right to left, which is converse to other schemes. In order to use the same encoding conversion module, we must change the storage direction first. The goal of UKK encoding analysis is to confirm corresponding letter from UKK information waiting to be analyzed. UKK information that has various kinds of UKK encoding schemes all has respective features with different numbers of encoding bytes, different range of encoding and storage direction. Therefore, before the auto analysis of UKK encoding, it is necessary to do some pretreatments, such as classifying the encoding and transforming the direction.

##### 3) Conversion of characters' encoding

When the information in UKK is checked, the key words' code must be obtained firstly, and then the pattern mat "Whenching" will begin. So it is important to convert the given format of code to other formats.

After the pretreatments above, according to the survey of this field, the conversion of encoding schemes are programmed and implemented with VS.Net, and key part of the codes are indicated as following box.

```

int[,] uCodesArray = {
0x327b ,0xcad0 ,0xcad2 ..... ,0xca9a ,0x32b2 };
private string ConvertUKKCodes(int nSourceType, int nTargetType, string SourceText)
{
    String TargetText = ""; int i;
    Char tmpChar, newChar;
    if (SourceText.Length > 0)
    {
        for (i = 0; i < SourceText.Length; i++)
        {
            tmpChar = SourceText[i];
            newChar = tmpChar;
            newChar = ConvertCodeFromSourceSys(nSourceType, nTargetType, tmpChar);
            if (newChar != tmpChar)
            {
                if (tmpOldText.IndexOf(tmpChar) == -1) tmpOldText = tmpOldText + " " +
                tmpChar;
                if (temNewText.IndexOf(newChar) == -1) temNewText = temNewText + " " +

```

The codes in the above box are significant part of converting different kinds of encoding schemes.

#### IV. EXPERIMENTAL STUDY

The following case is used to display how to use the software. Here is a target computer in which electronic data detective will find out the relevant information about “**خىنچان**” (spelled Chinese pinyin as Xin Jiang) from the computer storage media through utilizing the evidence-detecting tool EnCase.

In the tool of evidence detecting of Encase, key words can be set up by establishing new key words. New Keyword window will appear when KeyWord is chosen in the View of the EnCase main window, as shown in Figure 2.

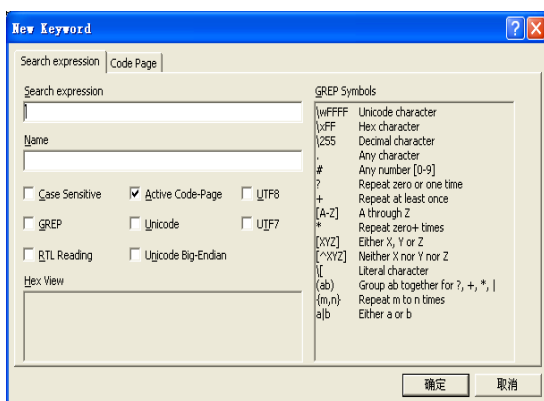


Fig.2 The New Keyword interface of EnCase

UKK information will not be supported when key words are entered into the “Search expression” block in Fig.(2). How can investigation be carried out by EnCase without the entry of UKK key words?

As forensic software, Encase itself can only provide limited functions by menu in that real cases vary and Encase cannot fulfill its functions through the utilization of menu. One of the advantages of Encase is that it provides EnCase programming script language (enscript) that provides investigators to write program for their special needs by using it. An investigator can build custom-designed scripts for specific investigative needs and can save his/her days or weeks of analysis time by using EnScript programming to automate almost any investigative task. These EnScript programs can also be compiled and shared by other investigators in the larger community [15]. EnScript so that some of the functions which cannot be carried out by Encase can be realized and meet the needs to achieve the goal of powerful function of automatic evidence finding. Encase offers a variety of useful manuscripts, which still cannot meet the needs in real work and which requires its users to write manuscript software so that Encase can be fully utilized.

In fact EnScript as a program written by users extends its functions is functioned through its own translation system, but not in other systems. There is a type named MainClass to be defined for any EnScript, at the same time, a function named Main has to be defined in MainClass. This function can be run (carried out) through utilizing EnScript offered by EnScript. The order Scripts in the menu of View in Encase main window is chosen at first. And then, with the pressing of the key Information the relevant code of EnCase Scripts will be set (made) in the right window. The following is its automatic frame code.

```
class MainClass
```

```

{
void Main(CaseClass case)
{
...
}
}

```

The key point in here is that how to use our tool to write the corresponding UKK key words. This task is implement and indicated as the following Figure 3.

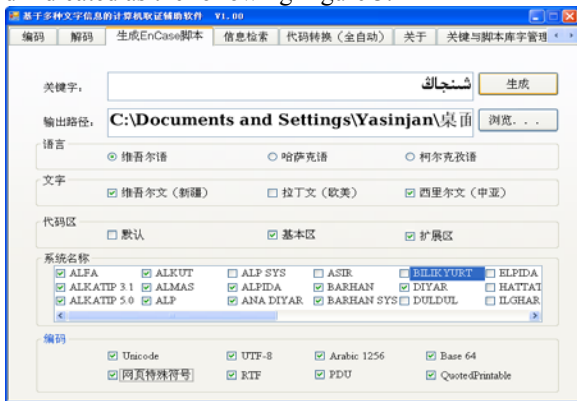


Fig.3 The Enscript creating interface of EnCase Assistant Tool

Then the file EnScripts named “ شەنجاڭ ” will be generated automatically in the chosen input route. And it can copy the EnScripts code generated by the tool software into the window of EnCase. Finally, it can import and run the EnScript as shown in Figure 4.

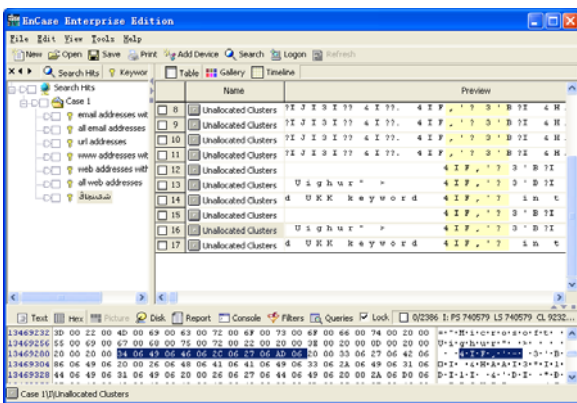


Fig.4 The Enscript interface (running) of EnCase

A lot of information is chosen after the order has been carried out as shown in Figure 4. But the problem here is that EnCase doesn't support UKK information and EnCase cannot be shown directly in Encase window. And the chosen information is copied and decoded by the function of “Decoding” button in the tool. It need select the target encoding scheme before conversion and decoding, and it summarized most of the types of UKK encoding schemes.

These operations are conducted by the related parts (buttons) of the window in the software shown as the following Figure 5.

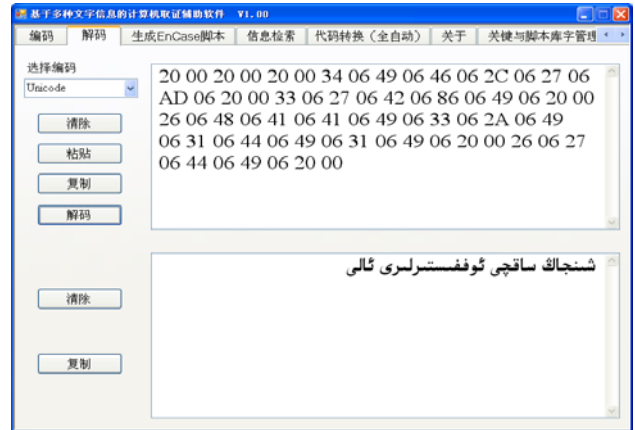


Fig.5 The code decoding interface of our EnCase Assistant Tool

From the above Fig.(5), it is indicated that the relevant information are obtained which user need in this window. Thus, it is attained the goal of computer forensics based on UKK information through the utilization of EnCase.

## V. CONCLUSION

According to principles of designing useful tool for computer forensics, it is summarized UKK information systems' working principle and their encoding schemes by conducting in-depth analysis on UKK information systems in this paper. After studying widely used encoding schemes and analyzing their document structure ( many kinds of document formats such as eot, uef, uwr, lwa, ipd, uof, udb, doc, txt, rtf, htm, html, mht, php, asp, aspx, etc), UKK encoding schemes are classified , and a uniform rule table is established. And then, EnCase script is generated by using UKK information via characters conversion, encoding conversion, encoding/decoding. It is successfully developed the Helper of EnCase based on the above works, and it has been tested for three years by computers judicial identification department. The experimental results indicated that the system can process UKK information effectively, and it is filled the blank which is UKK information can't be processed automatically in computer forensics field. The system indicates its convenience and efficiency in practical application.

We will optimize the system functions by further enlarge UKK encoding schemes in our future work, and will enhance other code structures in UKK information processing system and coding rules utilized in other applied programmer structures. It is focused the rarely used UKK information recorded in online chatroom tool in our next work.

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