

Analysis of ink-jet printing and seal timing experiment by confocal Raman spectroscopy

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Abstract. Confocal Raman spectroscopic technique has very important influence for the verification and identification of ink-jet writing and seal timing. In order to better discuss this technology, the related theories of this technology were first summarized in this paper. Scanning curves of Raman linewidth of different timing seals were compared. The results show that the Rapp spectral curve prints linewidth and timing have some relevance. Through questionnaires, the judicial personnel's approval degree of this technique can be further determined. The purpose of this study is to provide theoretical basis and technical support for follow-up research.

Key words. Confocal microscopy, Raman spectroscopy determination, ink-jet printing, seal timing.

1. Introduction

With the development of the times, the current social economy has made great progress and promotion. In this trend, each industry has gained more opportunities for development, which makes the development of the industry more comprehensive and scientific. However, with the rapid economic development of various industries, many uncoordinated phenomena have been further exposed. In the process of social development in the current era, some phenomena such as economic crimes and civil disputes appear. In the development of various industries, because some economic criminals alter the contract and some relevant notes, it is difficult to identify the whole late related materials, which causes certain restrictions for the late development of enterprises. Especially in some cases of economic crime, the validity and reliability of the investigation are reduced to a certain extent due to the alteration of

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these important materials and evidence. In addition, it has an impact on the overall fairness of justice, which makes the detection of judicial cases disturbed. Therefore, only a more accurate examination of the handwriting in relevant documents can effectively provide a more positive impact on the relevant case cracking, and become a key factor in cracking the case justice. Many scholars have begun to pay attention to the methods of identifying handwriting. However, the traditional handwriting identification may cause damage to the relevant testing documents, which makes the integrity of the physical evidence damaged. In this paper, the analysis and discussion of the more advanced confocal spectroscopic techniques are conducted to determine the more mature techniques and means for related handwriting identification.

2. State of the art

In the process of the development of the times, many enterprises and industries have been given some opportunities for development. However, with the rapid development of the industry, some cases of economic crimes or some civil disputes have made the evidence of certain document nature become the key to the detection [1]. In the evidence, because it can make some key handwriting fraud, it affects the detection credibility of the case. Therefore, many scholars begin to gradually use some related techniques to identify handwriting, which brings certain advantages and positive effects for the detection of the case [2]. Some scholars have used chromatography to identify some important documents. Although they have been some credible results, this method directly or indirectly causes a certain degree of damage to the documentary evidence, which makes the integrity and credibility of the relevant evidence subject to some doubt [3]. In this context, many scholars begin to put forward and further apply new detection technologies in the handwriting detection, such as confocal microscope Rapp spectroscopy. While carrying on the effective verification to the related handwriting, it also has promoted the reasonable explanation and the solution of industry economy crime, and provided certain technical support for the further development of the industries [4].

The relevant experimental design in this study is as follows:

(1) In the study, the laser scanning of the confocal Raman spectrometer was carried out for different ink jet printing fields at first. The related Raman spectra of the text in different fields were made, and the results were shown in Fig. 1. Wherein, the two rows of curves were the writing of the first section of ink jet printing field; the relatively flat four lines in the middle were the writing of the second section of ink jet printing field; the last two lines were the writing of the third section of the ink jet field.

(2) On the basis for accurate scanning fields in all of the paragraphs, the relevant documents were handled through the use of print and stamp different order. Processing methods mainly include two kinds of printing methods: the first print then stamp and the first stamp then print.

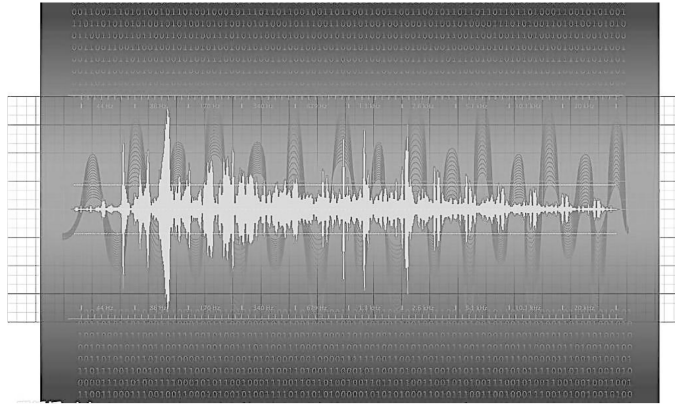


Fig. 1. Scanning confocal microscopy curves for different sections of inkjet printing fields

(3) All documents and materials were scanned by micro confocal Raman laser with different energy to determine the relatively stable laser energy, in order to prepare follow-up related experiments. Then, the SRS channel theory and the time series model in the confocal Raman spectroscopy were used to compare the laser scanning energies of different materials [7]. Through the calculation of the spectral curve, the accuracy and reliability of the confocal microscopy Raman spectroscopy and laser scanning technology in the identification of the relevant documents were further determined. Finally, through the introduction of actual cases, the actual analysis of related technologies was conducted to determine the related advantages and performance of this technology, and to provide some advantages for the promotion of technology. The related SRS signal channel theory and timing theory computational models were shown in formula (1) and (2). First, the digestibility of the relevant curves obtained by all scans was computed [8]. The correlation model is shown below:

$$x^{(3)}(\omega_p) = x_{NR}^{(3)} + \frac{x_R^{(3)}}{\Delta - iT}, \quad (1)$$

where, $x^{(3)}(\omega_p)$ is the polarizability obtained by scanning the related document data, $x_{NR}^{(3)}$ is the standard curve obtained after the determination of the multiple standard document value, $x_R^{(3)}$ represents the signal intensity measured values obtained after scanning the file, Δ represents the numerical value of the representative system and iT is the linewidth of the correlation curves obtained after scanning confocal Raman microscopy.

The scanning correlation coefficients of all curves were calculated by formula (2), and the formula is as follows:

$$I_{CARS} = \left\{ \left| x_R^{(3)}(\Delta) \right|^2 + \left| x_{NR}^{(3)} \right|^2 + 2x_R^{(3)} \operatorname{Re} \left[x_R^{(3)}(\Delta) \right] \right\} I_P^2 I_S Z^2, \quad (2)$$

where I_{CARS} are the calculated indexes values for all relevant parameter and $x_R^{(3)}(\Delta)$

mainly represents different signal intensities, including three main parts: resonant part, non-resonant part and the cross section. Symbols I_p^2 , I_s and Z^2 represent the probability coefficients, the speed coefficients and the curve deviation coefficients of the scanning transmission of the measured files, respectively.

Finally, through the investigation and analysis of some judicial investigation departments, the advantages of micro confocal Raman spectrometry in practical judicial investigation were further confirmed. The information related to the questionnaire was set out in Table 1.

Table 1. Main questionnaire setting information used in this study

| No. | Related questions setting | Excellent | Good | Poor |
|-----|---|-----------|------|------|
| 1 | Completeness of evidence obtained at the end of the scan | 10 | 5 | 3 |
| 2 | Reliability and accuracy of scanning after scanning relevant document data | 10 | 5 | 3 |
| 3 | The scanning method is easy to operate and related program and hardware operation performance | 10 | 5 | 3 |
| 4 | The credibility of the final result | 10 | 5 | 3 |
| 5 | The final resolution of the handwriting obtained in scanning the relevant document data | 10 | 5 | 3 |
| 6 | The ultimate effectiveness of judicial decisions | 10 | 5 | 3 |

3. Result analysis and discussion

Since entering the era of reform and opening up, the country's economic level has been greatly improved. The status of the state in the international community has increased gradually. In this trend, China's social industry has been a common development and promotion. Under the background of the rapid development of economic strength and comprehensive level, China's overall economic level has been improved greatly. However, many discordant phenomena are further exposed in this context [9]. China's economic crimes and civil disputes are gradually increasing with the promotion and progress of the economic level, which has made all sectors of China's common sustainable development restricted and hindered. In the relevant criminal activities, certain evidence documents cannot provide better evidence for the subsequent judicial review process after the writing has been altered [10]. Under this trend, many judicial departments begin to gradually introduce some novel handwriting data identification and scanning tools, and these tools are gradually applied to the actual document scanning, and certain results are achieved. However, with the development of criminals' false handwriting techniques in some materials, it has caused some difficulties for the identification of relevant documents. Thus, the fairness justice have been restricted to a certain extent, and the whole social environment and the steady development of economy have also been restricted [11].

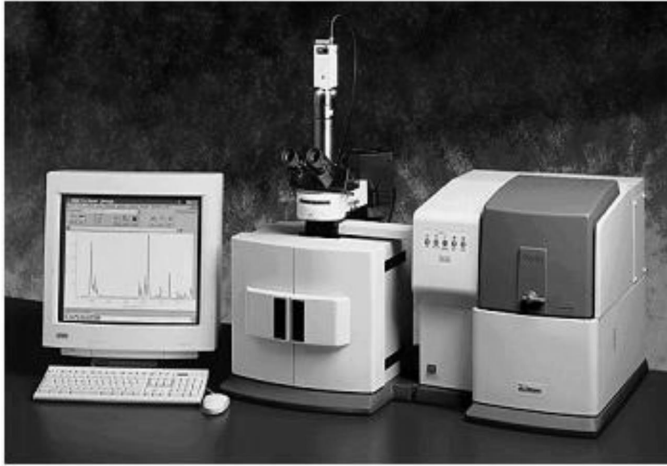


Fig. 2. Development of confocal Raman spectroscopy

Under the demand of the times, more new handwriting identification techniques are beginning to emerge. Especially, with the rapid development of computer technology, this new technology brings more important impetus and positive influence for the development of the handwriting identification technology of relevant documents. The technique of confocal Raman spectroscopy is higher than other handwriting identification techniques because of its high sensitivity to related handwriting identification and the reliability of relevant handwriting identification results in the development of today's times. Therefore, this technique has been gradually applied to the actual judicial identification, and it also ensures the integrity of the relevant evidence in the process of effective identification of relevant handwriting. Moreover, it provides some positive influence and impetus for the judicial justice to be more fair and complete, and gradually becomes the key handwriting identification technology in the current era [12]. The application of confocal Raman spectroscopy in handwriting identification is mainly based on the SRS effect theory. The main principles of the use of the theory are that when scanning certain handwriting by using confocal Raman spectroscopy, the scanning light produced by the relevant equipment or instrument touches some of the substances in the handwriting and scatters [13]. And most of the light does not change the elastic scattering due to the scattering wavelength associated with the writing medium. There is also a portion of the light that will be inelastic with the relevant documentation of the document's medium. When the light scattering does not have to dry, there will be micro confocal scattering. The main scattering process is shown in Fig 3.

In addition, there are many research find that different frequencies of light with blue and red shift occurs between the light and the writing medium Rapp in the process of Raman scattering by collisions of light with matter. And the whole scattering process shows the relative and weak process of light. Therefore, the frequency of this scattering phenomenon is also relatively low. In the light of Rapp enhancement-processing, the re-emergence of new superimposed light and scattering

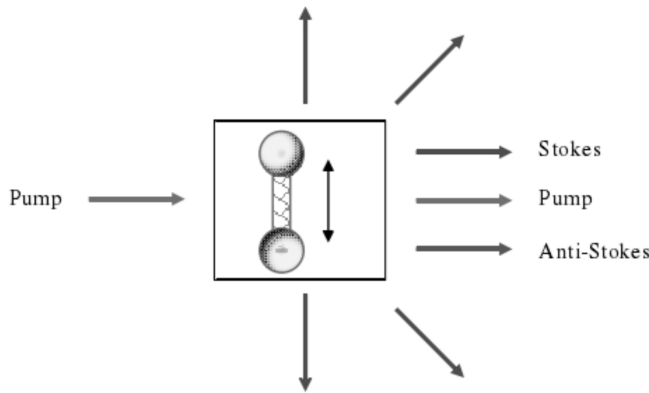


Fig. 3. Rapp light scattering process map

processes increases the ultimate efficiency of scattering, which is shown in Fig. 4 [14]. Therefore, this process is applied to the process of handwriting identification gradually. The light scattering efficiency of this increased the light scattering process may be about 105 times the average scattering efficiency of the process, and even shows a scattering of higher efficiency, which makes the final determination results have higher credibility, and provides a positive impact and impetus for the latter part of the handwriting verification [15]. It needs to be explained that the use this kind of technology considers energy of Rapp light, and analyze and discuss the final frequency on the scattering. Therefore, the accuracy of this technique is higher.

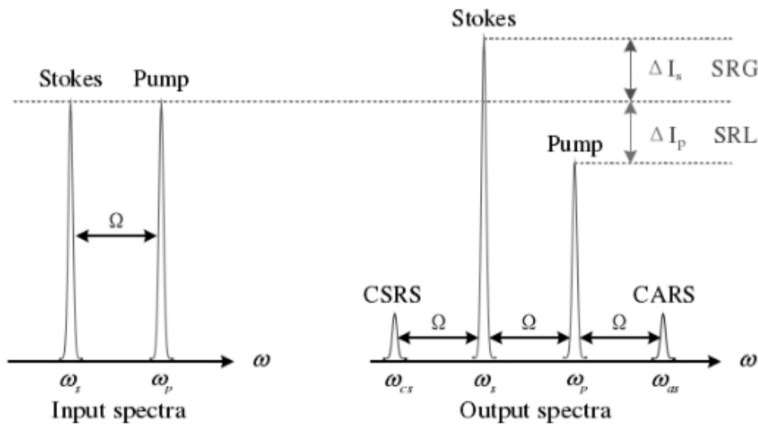


Fig. 4. Input and output spectrum of coherent light scattering process

On the basis of a clearer understanding of the relevant theories, a document was taken as an example for analysis in this paper. The micro confocal spectroscopy technique was used for Rapp jet to the file. All the fields and paragraph seals were scanned accurately. Then file data was processed through the experiment of different timing (first printed stamp and first cover printing printing). Finally,

measuring instrument spectral results by the confocal microscope Rapp spectra were analyzed. Relevant mathematical models were utilized to perform data calculations. The experimental results of two different timing were studied, such as the original spectral line scan results. The contrast results were shown in Table 2. The results showed that the line width of the scanning line of the original paragraph of different passages was analyzed with the results of the spectral line-width of two different time series after the input of the relevant parameters. The line width of the scan lines of all the segments was related to the processing time of the files. It could be seen through the results that line width of a segment scan line of the processing order of seal materials after the first print file was close to the width of the original file material. The first stamp printing order showed great difference relative to the original scanning line width. Research showed that this kind of technology could be used for timing analysis of ink-jet printing and print handwriting, and the result had certain reliability and accuracy.

Table 2. Linewidth analysis of scanning lines of different segments with confocal microscope spectroscopy

| Paragraph | Parameter input | | | Spectral line width result output | | |
|-----------|-----------------|-------|---------------------|-----------------------------------|------------------------|------------------------|
| | Peak center | Width | Area under the peak | Original | First print then stamp | First stamp then print |
| 1 | 2850.46 (3.44) | 28.41 | 24.45 | 9.34 | 8.24 | 5.33 |
| 2 | 2869.59 (10.39) | 33.97 | 26.94 | 15.62 | 14.55 | 10.49 |
| 3 | 2887.48 (13.41) | 33.30 | 23.15 | 16.93 | 16.47 | 14.50 |
| 4 | 2907.08 (16.46) | 40.61 | 28.31 | 18.95 | 17.98 | 13.22 |
| 5 | 2931.74 (10.59) | 53.24 | 72.94 | 18.86 | 18.01 | 15.14 |
| 6 | 2958.01 (11.00) | 39.04 | 18.92 | 13.93 | 13.37 | 11.27 |
| 7 | 2989.90 (14.94) | 40.61 | 8.77 | 5.87 | 5.22 | 4.95 |

Finally, through the questionnaire of a judicial unit staff survey, the main characteristics of confocal micro Raman spectroscopy and traditional scanning technology were compared, and the results in Table 3 and Fig. 5. The results showed that the confocal Raman spectroscopy technique had higher score than the traditional scanning technique, and it also indirectly indicated that the technique was more suitable for the scanning of document handwriting in modern times.

4. Conclusion

With the development of the times, today's various industries have been greatly improved. In the process of rapid development of various industries and enterprises, some uncoordinated phenomena such as economic crimes or civil disputes are gradu-

ally exposed. And the related text material is the more important link in the related judicial activity. However, with the progress of science and technology, a lot of criminals have the ability to fake relevant handwriting that has a certain confusion and negative influence on the judicial expertise. With this phenomenon, many handwriting identification techniques have been applied and some achievements have been achieved. Confocal micro Raman spectroscopy is used for the analysis and identification of ink-jet printing and the print timing, which is a kind of scientific technology. In this study, the main concepts of this technology were analyzed and different word processing methods were introduced as examples. Through the use of relevant models for settlement, the results were finally compared through the questionnaire method. The results show that this technique is of great importance to the identification of handwriting. However, due to the simple analysis of one technology, the study has a poor contrast and some defects. But it can provide a theoretical basis for further studies.

Table 3. Questionnaire results

| No. | Related questions setting | Raman spectra | Traditional techniques |
|-----|--|---------------|------------------------|
| 1 | Completeness of evidence obtained at the end of the scan | 8 | 4 |
| 2 | Reliability and accuracy of scanning after scanning relevant document data | 7 | 7 |
| 3 | Scanning method, operation simplicity and related program and hardware operation performance | 7 | 5 |
| 4 | The credibility of the final result | 9 | 4 |
| 5 | The final resolution of the handwriting obtained in scanning the relevant document data | 10 | 4 |
| 6 | The ultimate effectiveness of judicial decisions | 10 | 6 |
| 7 | Total | 51 | 30 |

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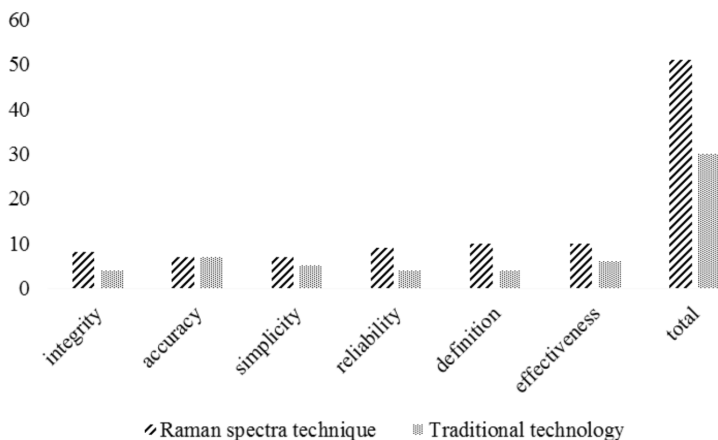


Fig. 5. Questionnaire results

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