

POLICE ASPECTS OF THE FORENSIC METHODS OF THE STUDY OF PERCENTAGE OF WATER CONTENT OF THE DETERMINE THE AGE OF THE FRESCOES

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The novels of the Criminal Procedure Code (CPC) Republic of Serbia have introduced the concept of prosecutorial investigation in relation to that of evidence, special evidentiary actions and other software for the operation of the criminal prosecution. The meaning of novels is to conduct harmonization of standards with solutions of modern criminal law practice, particularly with regard to EU standards Serbia applying for membership in the Union. Preventing the most serious forms of crime is the focus of authorized bodies Serbia and in this context combating and preventing all forms of forgery, as is the case with forgeries frescoes and selling them on the world market. In exposed paper the method determining age of the frescoes is proposed. It is based on the use of closed Markov's graphs with three cells. The measurements of contents of water molecules in surrounding area can be done only for the space in which the frescoes is located. This means that followed exposed method is non destructive.

KEY WORDS: Police, Forensics, Humidity concentration, Markov's graph, frescoes.

INTRODUCTION

After the social changes in Serbia in late 2000 launched a process of social reform, transformation of the police and state authorities, new and harmonization of legislation with the EU. Started the transition of Security sector reform and police, secret service and other subjects in the national security.

In the field of criminal law is modelled on the developed world adopted several new regulations, such as the Penal Code, Criminal Procedure Code, the Law on Confiscation of the Proceeds from Crime, Law on organization and jurisdiction of the authorities in combating organized crime, corruption and other most serious forms of crime.

In the field of criminal procedural law adopted a new Code of Criminal Procedure (1), which has been repeatedly amended and supplemented, and was modelled on the German model finally adopted the amended text that introduces into practice the concept of prose-

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cutorial investigation. According to this model, the state (public) prosecutor shall conduct the investigation and preliminary investigation procedure (1, Art.43-49) and it's subordinate to the police and all authorities at that stage. The state prosecutor ordered the police implement specific actions in the function of collecting evidence (1, Art.285), and in this respect the police acts and has specific powers (1, Art.286-294) that are characteristic police standard, criminal and other. At present the CPC of evidence (1, Art.85-160) as well as hearing the defendant, the hearing of witnesses, expert analysis, investigation, verification of documents, checking accounts and suspicious transactions, seizure and search of objects (people, things, a). In accordance with the Convention against Transnational Organized Crime (Palermo Convention) (2) in CPC are built special evidentiary actions (2, Art.161-187), such as secret surveillance of communication, secretly monitoring and recording, computer search data, controlled delivery and covert coroner.

For the purpose of this paper is of particular importance is the expertise, evidentiary action (2, Art.113-132). In order to determine forgeries frescoes, other works of art and rare objects of special importance sampling as a method of expertise in a broad sense.

Determining of age of the frescoes is very important problem. This problem becomes very serious since the number of forgeries and forgers increases permanently. Control whether the paint is original or forgery is complicated by the fact that during analysis the paint should not be damaged.

It is the reason why we propose a method which is not destructive (in the sense of damaging of the frescoes). The method consists in determining of humidity contents i.e. in measuring of ppm of molecules water expressed in per cents. This method is applicable in all cases, because the paint and its environment always contain some per cent of molecules water. The paint and environment exchange molecules of water and therefore humidity per cent changes in time.

Since the room is not hermetically isolated of wider environment this fact must be taken into account from the moment of creation. It is obvious that the exchange of water molecules between room and wider environment influences the humidity of the frescoes.

The Marcov's graphs will be used in calculations. The graphs will have three cells and will be closed. The cells correspond to the paint, to the room and to wider environment. The fact that the system is closed means that the sum of concentrations will be constant in time. The choice of closed system in the same time means that the effects of absorption of water molecules by walls, furniture etc. are neglected, although they really exist.

GENERAL REMARKS ABOUT FORGERIES AND FORENSIC EXPERTISE OF FRESCOES

We considered two approaches:

(a) *Falsification* of art, rare items and weapons (old and trophy) is a phenomenon that is now very much in the world and brings enormous profits for all participants in the criminal chain. On the other hand, the customers, the state and the international community are equally damaged by this kind of crime because it distorts economic interests, originality and value of artworks and objects Raritan. An additional problem is the foreign elements of these offenses, which leads to the necessity of cooperation among all countries and international organizations.

Art Mafia is now synonymous with organized criminal groups engaged in both the theft and resale of original paintings and rare objects, as well as forgery and selling these items on the market (3). The organization brings together a wide circle of people – thieves, forgers, perpetrators, transporters and other participants in the criminal chain that connects a common goal - the achievement of extra profits.

The fight against counterfeiters includes measures at national and international level, both normative and operational. Certainly the most important role is played by Interpol as the International Criminal Police Organization, which consisted of specialized line of work that follows forgeries, smuggling and all forms of crime in this and related fields (4). Interpol coordinate joint actions and take other measures and actions as well as invitations to national police (Romania - forger stolen art objects, Lithuania-list of damaged and owners, Poland and Norway - Project Joint investigation teams for legal and smuggled heritage), international meetings (IX International meeting on theft and smuggling of art objects, cultural treasures and antiques-Lion, 11-13-03.2015), cooperation with specialized agencies (UNESCO Venice Office, SEE, EU, private sector), the publication of Protection of the National Convention of the goods (Mali and Bhutan, 18.02.2013), posters (The Most Wanted Works of Art, Dec. 2014), meetings of the expert group (IEG - Interpol Expert Group, 27-28.02.2014. (5)), the publication of stolen goods from war zones (Afghanistan, Iraq), a special international standard (Object ID) containing a description and characteristics of object recognition, the International Red List of ICOM (International Council of Museums, Red Lists) archaeological objects, vulnerable regions and localities from which they steal, smuggle and resale cultural objects and others. A list is compiled with the help of Getty International Institute continues to deliver International Council of Museums.

b) *Counterfeits* frescoes in the above sense are rare, but as forms of crimes and present the subject of attention of professional and general public. Because of the special values, historical, cultural and other reasons, it is extremely important work state Officials involved in the discovery of these works and their further processing. The detection of counterfeit is particularly important forensic work and the use of appropriate forensic methods, which help obtain material evidence and provides the basis for the prosecution of perpetrators.

BASIC FORMULAS DETERMINING HUMIDITY

In the previous section it was said that the analysis will be based on closed Marcov's graphs with three cells.

The mentioned graph is given on Figure 1.

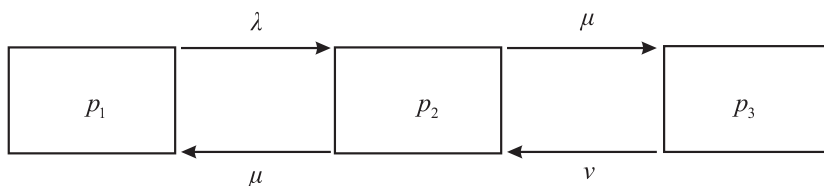


Figure 1. The closed Marcov's graph with three c

On this graph p_1 represents concentration of water molecules in the frescoes, p_2 is concentration of water molecules in the room while p_3 is concentration water molecules in wider environment.

Scheme on Figure 1 represents graphical algorithm for forming the system of differential equations determining time dependence of concentrations p_1 , p_2 and p_3 . This system is as follows:

$$\begin{aligned} \dot{p}_1 &= -\lambda p_1 + \mu p_2 \\ \dot{p}_2 &= -2\mu p_2 + \lambda p_1 + \nu p_3 \\ \dot{p}_3 &= -\nu p_3 + \mu p_2 \end{aligned} \tag{2.1}$$

where λ , μ , ν are distribution frequencies. Summing these equations we obtain that

$$\dot{p}_1 + \dot{p}_2 + \dot{p}_3 = \frac{d}{dt}(p_1 + p_2 + p_3) = 0$$

wherefrom it follows that:

$$p_1(t) + p_2(t) + p_3(t) = const. \tag{2.2}$$

The last formula is the proof that Marcov's graph is closed.

The system of differential equations [2.2] can be translated into system of linear algebraic equations by means of Laplace's transformation (6, 7). It means that all equations of the system [2.1] will be multiplied with $e^{-\omega t}$ and integrated with respect to t from zero to infinity. The described procedure gives the system of algebraic equations:

$$(\omega + \lambda)q_1(\omega) - \mu q_2(\omega) = p_1(0) \tag{2.3}$$

$$-\lambda q_1(\omega) + (\omega + 2\mu)q_2(\omega) + \nu q_3(\omega) = p_2(0) - \mu q_2(\omega) + (\omega + \nu)q_3(\omega) = p_3(0)$$

The notation used in [2.3] is:

$$q_s(\omega) = \int_0^{\infty} dt e^{-\omega t} p_s(t), \quad s = 1, 2, 3 \tag{2.4}$$

The formula:

$$q_s(\omega) = \int_0^{\infty} dt e^{-\omega t} \dot{p}_s(t) = \omega q_s(\omega) - p_s(0), \tag{2.5}$$

$s = 1, 2, 3$

was used, also. The solutions of the system [2.3] are given by:

$$\begin{aligned} q_1(\omega) &= \frac{p_1(0)\omega^2 + [(2\mu + \nu)p_1(0) + \mu p_2(0)]\omega + \mu\nu H}{\omega(\omega - \Omega_1)(\omega - \Omega_2)} \\ q_2(\omega) &= \frac{p_2(0)\omega^2 + [(\nu + \lambda)p_2(0) + \lambda p_1(0) + \nu p_3(0)]\omega + \lambda\nu H}{\omega(\omega - \Omega_1)(\omega - \Omega_2)} \end{aligned} \tag{2.6}$$

where $H = p_1(0) + p_2(0) + p_3(0)$ and

$$\Omega_1 = -\frac{2\mu + \nu + \lambda}{2} + \frac{1}{2}\sqrt{4\mu^2 + \nu^2 + \lambda^2 - 2\nu\lambda} \tag{2.7}$$

$$\Omega_2 = -\frac{2\mu + \nu + \lambda}{2} - \frac{1}{2}\sqrt{4\mu^2 + \nu^2 + \lambda^2 - 2\nu\lambda} \tag{2.8}$$

Time dependance of concetrations $p_s(t)$; $s = 1, 2, 3$ can be found by application of inverse Laplace transformation (8):

$$p_s(t) = \frac{1}{2\pi i} \int_{c-i\infty}^{c+i\infty} d\omega e^{\omega t} q_s(\omega), \quad s = 1, 2, 3 \quad [2.9]$$

The contour in complex ω plane for calculation of Bromvich integral (9,10) is given on Figure 2.

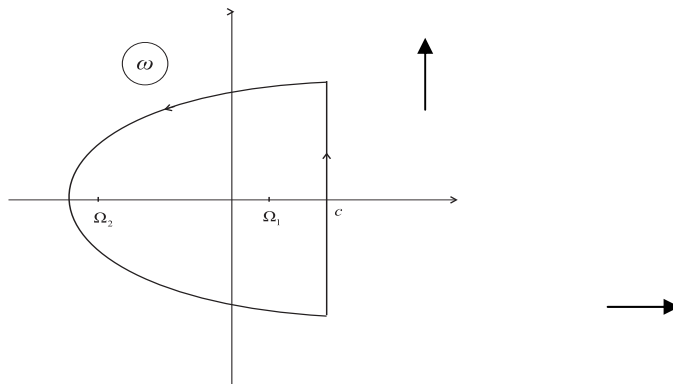


Figure 2. Contour in complex plane for finding of inverse Laplace transformation

Since all functions $q_s(\omega)$ have three simple poles $\omega=0$, $\omega=W_1$ and $\omega=W_2$, the integral [2.9] is sum of residues in poles 0, W_1 and W_2 . The formula for finding of residuum at simple pole is:

$$\text{Res} f(z) = \lim_{z \rightarrow z_0} (z - z_0) f(z) \quad [2.10]$$

Applying the formulas [2.9] and [2.10] to [2.6] we obtain the solutions of the system of differential equations [2.]:

$$p_1(t) = \frac{\mu\nu H}{\Omega_1 \Omega_2} + \frac{p_1(0)\Omega_1^2 + [(2\mu + \nu)p_1(0) + \mu p_2(0)]\Omega_1 + \mu\nu H}{\Omega_1(\Omega_1 - \Omega_2)} e^{\Omega_1 t} - \frac{p_1(0)\Omega_2^2 + [(2\mu + \nu)p_1(0) + \mu p_2(0)]\Omega_2 + \mu\nu H}{\Omega_2(\Omega_1 - \Omega_2)} e^{\Omega_2 t} \quad [2.11]$$

$$p_2(t) = \frac{\lambda\nu H}{\Omega_1 \Omega_2} + \frac{p_2(0)\Omega_1^2 + [(\lambda + \nu)p_2(0) + \lambda p_1(0) + \nu p_3(0)]\Omega_1 + \lambda\nu H}{\Omega_1(\Omega_1 - \Omega_2)} e^{\Omega_1 t} - \frac{p_2(0)\Omega_2^2 + [(\lambda + \nu)p_2(0) + \lambda p_1(0) + \nu p_3(0)]\Omega_2 + \lambda\nu H}{\Omega_2(\Omega_1 - \Omega_2)} e^{\Omega_2 t} \quad [2.12]$$

$$p_3(t) = \frac{\lambda\mu H}{\Omega_1\Omega_2} + \frac{p_3(0)\Omega_1^2 + [(2\mu + \lambda)p_3(0) + \mu p_2(0)]\Omega_1 + \lambda\mu H}{\Omega_1(\Omega_1 - \Omega_2)} e^{\Omega_1 t} - \frac{p_3(0)\Omega_2^2 + [(2\mu + \lambda)p_3(0) + \mu p_2(0)]\Omega_2 + \lambda\mu H}{\Omega_2(\Omega_1 - \Omega_2)} e^{\Omega_2 t} \quad [2.13]$$

These formulas will be used for determining of the age of the frescoes.

DETERMINING AGE OF THE FRESCO

Determining of age of the fresco requires series of measurements of water contents. It should be pointed out that we do not know when was the initial momentum $t = 0$, since we do not know when the fresco was finished. Consequently, initial concentrations $p_1(0)$, $p_2(0)$ and $p_3(0)$ are unknown. There is a possibility to determine initial concentration of H_2O molecules in the fresco using computer scheme of paint distribution of fresco. With help of this scheme we can reproduce paints of investigated fresco and measure its humidity. It could be equal to initial concentration $p_i(0)$.

Concerning measurements we must remember that the fresco must not be damaged, which means that no measurements should be done on the fresco. It also means that the formula [2.11] will not be used. Measurements of humidity percentage of wider environment are not recommended due to the possible fluctuations of humidity in wider area (rain, snow, wind etc.). On the bases of above reasoning it remains to measure H_2O contents in different moments in time in the room where the fresco is located. The humidity fluctuations in the room are very rare. Besides, the paint is in direct contact with air of the room (see Markov's graph). This direct contact gives more perceptible changes of humidity. Since the wider environment and the paint are not in direct contact, the changes of humidity of wider environment $p_3(t)$ would be weak, and this requires longer time intervals between two consecutive measurements. The final conclusion from preceding discussion is that all measurements are related to determining the concentrations $p_2(t)$. The first measurement concentration p_2 gives $p_2(T)$, where T is the age of the fresco in the moment of measurement. This concentration will be denoted with B_1 .

On the basis of the formula [2.12], written for $t = T$ we get the following expression formula:

$$R = \frac{B_1 - \Phi(x, y, T, B_0) - F(x, y, T, z, H)}{2 \sinh yT} e^{xT} \quad \& \quad f(x, y, z, T, H, B_0) \quad [3.14]$$

Where

$$x = \frac{2\mu + \nu + \lambda}{2}, y = \frac{1}{2} \sqrt{4\mu^2 + \nu^2 + \lambda^2 - 2\nu\lambda}, z = \nu\lambda, B_0 = p_2(0), B_1 = p_2(T) \quad [3.15]$$

The functions Φ and F , figuring in [3.14] are given by:

$$\Phi(x, y, T, B_0) = B_0 \frac{y \cosh yT - x \sinh yT}{y} e^{-xT} \quad [3.16]$$

$$F(x, y, T, z, H) = \left[\frac{1}{x^2 - y^2} - \frac{x \sinh yT + y \cosh yT}{y(x^2 - y^2)} e^{-xT} \right] zH \quad [3.17]$$

The time unit in the formula [3.14] is one year. There appear six unknown values in [3.14]: x, y, z, T, H and B_0 . To determine these unknown parameters, we must carry out six measurements of concentration $p_2(t)$. The interval τ between two consecutive measurements can be taken to be one month, or half a month. In the first case $\tau = 1/12$ and in the second case $\tau = 1/24$. The first of these measurement must be done a month or half amount after the first measurement which has got value $B_1 = p_2(t)$.

The values of concentration obtained in moments $T + \tau, T + 2\tau, \dots, T + 6\tau$, will be denoted by B_2, B_3, \dots, B_7 , respectively. So we obtain the following system of the equations:

$$\begin{aligned}
 B_2 &= F(x, y, T + \tau, z, H) + \Phi(x, y, T + \tau, B_0) + [2e^{-x(T+\tau)} \sinh(T+\tau)] f(x, y, z, T + \tau, H, B_0) \\
 B_3 &= F(x, y, T + 2\tau, z, H) + \Phi(x, y, T + 2\tau, B_0) + [2e^{-x(T+2\tau)} \sinh(T+2\tau)] f(x, y, z, T + 2\tau, H, B_0) \\
 B_4 &= F(x, y, T + 3\tau, z, H) + \Phi(x, y, T + 3\tau, B_0) + [2e^{-x(T+3\tau)} \sinh(T+3\tau)] f(x, y, z, T + 3\tau, H, B_0) \\
 B_5 &= F(x, y, T + 4\tau, z, H) + \Phi(x, y, T + 4\tau, B_0) + [2e^{-x(T+4\tau)} \sinh(T+4\tau)] f(x, y, z, T + 4\tau, H, B_0) \\
 B_6 &= F(x, y, T + 5\tau, z, H) + \Phi(x, y, T + 5\tau, B_0) + [2e^{-x(T+5\tau)} \sinh(T+5\tau)] f(x, y, z, T + 5\tau, H, B_0) \\
 B_7 &= F(x, y, T + 6\tau, z, H) + \Phi(x, y, T + 6\tau, B_0) + [2e^{-x(T+6\tau)} \sinh(T+6\tau)] f(x, y, z, T + 6\tau, H, B_0)
 \end{aligned}
 \tag{3.18}$$

Besides, in order to find the age of the paint T , which is the main goal of our analysis, we must find the distribution frequencies μ, ν and λ . These frequencies cannot be calculated directly from the formulas [3.18]. They can be determined with the help of the values of x, y and z which are included into [3.18]. Knowing x, y and z , we can find μ, ν and λ from the relations [3.15]. The solving of the system of equations [3.18], requires the use of numerical methods. The same requires the solving of the system [3.15]. Finishing this section we quote the following illustrative example:

For: $\tau = 1/24$;

$$\begin{aligned}
 B_1 &= 2.7; B_2 = 2.7002; B_3 = 2.7005; B_4 = 2.7007; \\
 B_5 &= 2.70085; B_6 = 2.70095; B_7 = 2.701;
 \end{aligned}
 \tag{3.19}$$

we obtained:

$$T = 65.25 \text{ years}; H = 10; B_0 = 1.93; x = 0.12547; y = 0.005966; z = 0.000047 \tag{3.20}$$

Substituting [3.20] into [3.15], we found the values for distribution frequencies:

$$\lambda = 0.011179; \mu = 0.004847; \nu = 0.04221.$$

It is seen the results obtained in this example are realistic (11,12).

CONCLUSION

Because of the special values, historical, cultural and other reasons, it is extremely important work state Officials involved in the discovery of these works and their further processing. The detection of counterfeits is particularly important forensic work and the use of appropriate forensic methods, which help obtain material evidence and provides the basis for the prosecution of perpetrators.

The proposed method of determining the age of the frescoes has given satisfactory result: the age T can be determined without touch on the paint. The theory is based on really existing situation. Some idealizations are introduced by the fact that closed Markov's graph is used. This eliminated actually existing effect consisting of influence of walls, furniture etc. to the humidity of room. The main shortage of this approach is the moment of selling the fresco, since it occurs out of the room included in our theory. In quoted illustrative example only one set of six values B was used. In practice the more realistic result could be obtained with n sets of six values B . These n sets would be obtained by changing of intervals τ between two successive measurements. In this way we should obtain n sets of results of the type [3.20]. The values given in [3.20] would be calculated as arithmetic means of n values or as expectable values of them.

Acknowledgement

This work was supported by the Serbian Ministry of Education, Science and Technological Development, Grant No. TR34019.

The authors owe special gratitude to his teacher, academician prof. dr Bratislav Tošić.

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ПОЛИЦИЈСКИ АСПЕКТИ ФОРЕНЗИЧКИХ МЕТОДА СТУДИЈЕ ПРОЦЕНТА САДРЖАЈА ВОДЕ КОД ОДРЕЂИВАЊА СТАРОСТИ ФРЕСАКА

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Новеле о кривичном поступку (ЗКП) Републике Србије имају уводни концепт тужилачке истраге у вези са овим доказима, посебне доказне радње и други софтвер за функционисање кривичног гоњења. Значење новела је да спроведе усклађивање стандарда са решењима савременог кривичног закона у пракси, посебно у вези са стандардима ЕУ Србије, која се пријављује за чланство у Унији. Спречавање најозбиљнијих облика криминала је фокус надлежних органа Србије и у том контексту је спречавање и борба против свих облика фалсификата, као што је случај са фалсификатима фресака и уметничких слика и њихова продаја на светском тржишту. У изложеном раду је предложен метод одређивања старости фресака. Он се заснива на коришћењу затворених Марковљевих графова са три хелије. Мерења садржаја молекула воде у околини може се урадити само за простор у коме се налазе фреске. То значи да је следећи изложени метод који се користи – неструктиван.

Кључне речи: Полиција, фореника, концентрација влажности, Марковљеви графови, фреске.

Received: 9 February 2015.

Accepted: 15 July 2015.