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Possibilities of Using Neural Networks in the Investigation of Crimes

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The study tested possibilities of using neural networks on the example of different models like, online analytical processing, data mining and knowledge discovery, specific models in the sphere of biology, models which can be used with biometric identification, face recognition systems, ECG recognition models and others. The main point of the study is technical development of scientists in the fields of specific sciences. The final results of the studied technical solutions, if they used correctly, can improve the quality of any investigation. Detailed analysis and comparison of different neural models reveal the strengths and weaknesses of each of them, as well as the their limitations. As a result, the study concludes relevance and perspective of various approaches for different kind of crime investigation.

Keywords: Neural network, forensics, crime investigation, biometric identification, face recognition, ECG recognition.

Research area: forensics; forensic activities; operational search activities.

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According to the opinion of Professor Igor Mikhailovich Komarov, artificial neural networks (hereinafter referred to as ANN) are a kind of mathematical model converted into a programme in any programming language. This model is based on the principle of action of the biological neural model (similar to the way of human brain functioning). The professor notes that "a multi-layered neural network … finds its use in the so-called 'deep machine learning', which allows modelling abstractions of

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high-level order". As noted by O. M. Gafurov (2013), one advantage of neural networks is the "capability of all elements parallel functioning". Programmes that simulate mathematical abstraction to solve a variety of tasks are useful for forensic science: this includes recognising written and oral speech, emotional state, and other objects that require analysis when searching for a person by appearance, predicting the course of an investigation, etc. The development of such neural networks will make it possible to reach the creation of full-value artificial intelligence capable of self-learning and, as Alexander Yakovlev suggests, grant a useful assistant in crime investigation. This will be possible while neural networks "learn from experience, summarise previous precedents for new cases and extract essential properties from incoming information containing redundant data".

Professor of the Department of Intellectual Systems Management at National Research Nuclear University (Moscow Engineering Physics Institute) Sergei Kulik noticed that creation of special algorithms implemented by neural networks significantly improved examinations that previously had been time consuming. For example, now there is a possibility for creating a psychological portrait of a person based on mathematical models expressed in the programme. Vladimir Spitsyn, Professor of the Computer Science Department of the National Research Tomsk Polytechnic University, noted that we use neural networks in the biological cell recognition procedure, which is also important for forensic science.

When there are too much source data or a lack of data, a criminal investigator simply cannot outline the most important one without losing the slightest details, therefore a set of methods for "hidden" information search was developed, called Data Mining and Knowledge Discovery, allowing to detect non-trivial information required for crime investigation at the programme level.

According to S. N. Nefedov, V. A. Parkhimenko and M. M. Tatur (2017) this method is based on "online analytical data processing (OLAP)", mathematical statistics, artificial intelligence self-learning procedures and is used for "intellectual decision-making support" by a criminal investigator for a specific crime under investigation.

Next, let us consider what specifically allows identifying DM&KD, what tasks it solves. The first task is to classify the studied objects based on certain features. This is the distribution of classes, those already known and those that were previously unknown. S. N. Nefedov gives an example of the classification of individuals according to the level of income and expenses, from which we can draw conclusions about persons with suspicious expenses or suspicious incomes.

The next task is clustering. It continues the classification, but has a more complicated procedure. Distributing something, for example, the crimes by clusters, the programme generates previously not pre-defined groups, from the content of which conclusions can be drawn, for example, which divisions need special equipment to investigate a particular group of crimes.

The search for association patterns includes looking for connections between events (co-occurrence, common features, etc.), which certainly helps forensic investigators in investigating complex multi-factor cases. DM&KD solves such problems in the process of searching for interdependencies between events related to each other in time. Figuratively, it can be represented as an algorithm — if A, then B, if B, then C, and so on. This technique is used in the investigation of crimes related to remittances and financial operations on money laundering.

This is followed by ranking (the distribution of events from the possible to the impossible, etc.). Thus, one massive criterion undertakes another one and we distribute objects among themselves. After this, the main task of forecasting is carried out and we draw conclusions about something that may happen in future, having some previously processed data. We can solve this problem using the regression method, "a quantitative assessment of the statistical relationship between two signs of homogeneous objects". For example, a forensic scientist needs to find out what is the relationship between the level of wages and crimes related to money trafficking; with the help of the programme, they can check their assumptions and see them in a numerical version.

Thus, the DM&KD method allows the forensic scientist to solve a whole layer of issues, simplifying the procedure of crime investigation. Application of this methodology would be impossible without neural networks capable of processing a significant amount of information in the software version. At the moment there are the following software products: 1) IBM I2 COPLINK — a whole software system that allows to search for suspects, analyse activity by territory and people, compare real people with identikits, produce statistical calculations, analyse the connection between crimes and terrain; 2) Hitachi's Predictive Crime Analytics (PCA) — finds the most criminogenic zones in a certain area and marks them on a map; 3) Financial Crimes Enforcement Network AI System (FAIS) — The US Treasury Department uses this neural network to investigate financial crimes. These are just some programmes (neural networks) used at the moment to facilitate the investigation of crimes that have been committed and to prevent the commission of new crimes.

Before the creation of a neural network, handwriting algorithms were used to study handwriting. The accuracy of the data analysis depended directly on the professionalism of an expert and the quality of materials. According to Yu. I. Eremenko and A. A. Shatalov (2013), there is still no ideal model for studying handwriting, but neural networks and artificial immune systems showed the best result. According to the authors of the article "Immune algorithm of multiclonal selection in solving handwriting identification problems", these systems are sometimes used with a neural network. According to L. N. De Castro and F. J. Von Zuben (see the article by Yu. I. Eremenko), the algorithms of the IIS apparatus based on the principle of "molecular recognition", suit best for the analysis of Russian-language text.

Yu. I. Eremenko notes that at the moment there are developments in three directions: 1) Utpal Garain, Mangal P. Chakraborty and Dipankar Dasgupta promote the theory of "clonal selection"; 2) V. I. Litvinenko, A. A. Didyk and Yu. A. Zakharchenko defend the theory of "Erne idiotypical networks"; 3) Julie Greensmith, Uwe Aickelin and Gianni Tedesco are working on the "theory of danger".

Based on these theories, scientists and programmers are developing algorithms that will allow forensic scientists to analyse handwriting using computer power (IMS, neural networks). Working on the theory of clonal selection, scientists have developed a CLONALG algorithm, advocates of the theory of Erne networks created AINet algorithm, which has the possibility of "clonal compression". The theory of danger became the basis for the development of the DCA algorithm (binary classifier). The development of these theories reached their height with the "multiclonal selection" algorithm, which allowed to analyse the handwriting. A. A. Shatalov gives an example of a programme capable of producing such an analysis — this is a Qt programme built based on the SDI template.

Neural networks can be used as part of a handwriting research algorithm. For example, S. D. Kulik and N. E. Gunko describe an algorithm called ASOIB, which allows to "set the characteristics of the performer of the document". At the fifth stage of the algorithm (there are only 8 stages), the authors proposed to classify the signs using a neural network. Upon completion of the algorithm, they concluded about the effectiveness of the neural network as a stage for the ASOIB algorithm.

We also use neural networks for biometric identification. A. K. Jain, A. Ross, S. Prabhakar (see the article by S. D. Kulik) explain that biometrics implies the ability to recognize a specific person by physiological or behavioural features. According to A. A. Astapov (2016) biometric uses fingerprints, iris, face and thermogram, DNA, voice,

gait, and more. Studies of the iris, according to A. V. Drozdova, is one of the priorities in biometric identification. This is because in the world "it is impossible to find two people with the same faces," V. V. Krivenko (1991) notes while the iris of the eye is "completely unique and individual". Russian scientists I. N. Tretyakov and N. N. Minakov (2010) are working in the field of information security and are investigating the possibility of using a neural network to identify people by the iris of the eye.

As for the identification of a person by face A. A. Andreeva and A. L. Ivanov (2006) noted that the scientists Resfield, Yeshurun and Tankus have already developed a "symmetry operator" and a "low-level generalising operator" used to detect and recognise a human face. They use these operators, including the use of neural networks. They train each neural network to recognise a separate area of the face, for example, one network analyses the central part of the face, the other only the eyes, etc. The experiments cited in the article by A. A. Andreeva and A. L. Ivanov (2006) prove the effectiveness of the use of neural networks in conjunction with other methods. Recognition of a person by face also includes facial expression recognition. Yu. T. Kaganov, A. M. Mokrov and N. V. Mokrova (2016) show the existence of some systems based on neural networks that can investigate crimes. For example, the FaceReader system (the Russian equivalent — EmoDetect) recognises human emotions, and the FaceSecurity programme carries out operational search activities on models in databases. The authors named above have developed their own algorithm of "adapting and training artificial neural networks", which, in their opinion, can be applied in various fields of activity, including forensic science.

Since some features require long analysis, while others can change under the influence of internal or external factors, some scientists have moved to the study of ECG, i. e. the electrical activity of the heart. The activity of the heart also changes, so measurements of its activity are made every day. T. Segaran claims that the "vector method and neural networks" are used for human ECG recognition. A. A. Astapov says that in 2010 a group of scientists led by J. L. Ch. Loong conducted ECG studies using the classification with neural networks, using two algorithms — WPD and LPC. They trained the network in algorithms, the main task assigned to it was to "propagate error signals from the network outputs to its inputs in the opposite direction to direct signal propagation in normal operation". As a result, the network could establish the superiority of the LPC method over WPD.

Thus, methods of research of the iris of the eyes and ECG have not yet fully developed and cannot be applied in the practice of forensic experts in the fight against

crime. However, studies conducted by many specialists in this field clarify that the future of the neural networks in human recognition using the iris and ECG is clear.

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Возможности использования нейронных сетей при расследовании преступлений

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В ходе исследования были проверены возможности использования нейронных сетей на примере различных моделей, таких как онлайн-аналитическая обработка, интеллектуальный анализ данных и обнаружение знаний, специализированные модели в области биологии, модели, которые можно использовать с биометрической идентификацией, системы распознавания лиц, модель распознавания ЭКГ и др. Окончательные результаты изученных технических решений, при правильном их использовании, могут улучшить качество любого расследования. Посредством анализа и сравнения различных нейронных моделей выявлены сильные и слабые стороны, а также ограничения каждой из них. В результате исследования сделан вывод об актуальности и перспективности вариативных подходов к разным видам расследования преступлений.

Ключевые слова: нейронная сеть, судебно-медицинская экспертиза, расследование преступлений, биометрическая идентификация, распознавание лица, ЭКГ-распознавание.

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