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A systematic approach to increase confidence in the diagnosis of muscle asymmetry

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Abstract

Asymmetry is one of the most widespread pathologies of the neuromuscular system. Depending on the composition of the same body from different types of muscles, as well as the fact that it does not seem so dangerous in the initial phases, the asymmetry is determined in clinical conditions, especially in severe phases. This requires long-term and sometimes painful treatment. The goal of the research is to detect the mentioned pathological condition at the initial stages. For this purpose, is designed a system that allows decision-making by applying several methods used to determine asymmetry.

Keywords: Electromyography; Muscle asymmetry; Systematic approach; Diagnosis

1. Introduction

At present, the application of various methods to the analysis of biomedical signals leads to an increase in the accuracy of decision-making. Among such approaches, the use of machine learning and artificial intelligence methods can be mentioned. The design of digital signal processing systems without a basic mathematical understanding of the signals and its properties is hardly possible. Moreover, they "guide" the user to implement, modify or even develop signal analysis tools. Many classical signal analysis tools are not suitable for finding relationships in large data sets. Deep learning, which is inherently machine learning, is opening up new opportunities in biomedical signal analysis. These issues were also reflected in [1]. Deep learning techniques usually use adaptive elements. These elements can process different input data, e.g. for classification. Learning, which can be supervised, semi-supervised or unsupervised, changes the structure of the system by changing the weights/connections between the information processing elements (artificial neurons) of the system. This change is data-driven as opposed to task-specific algorithms.

However, there are many questions concerning deep learning, e.g.: 1) Which method might be useful in biomedical signal analysis? 2) Why do some methods fail, but others not? 3) Can the structure and functionality of a successfully trained deep learning system be used to derive new signal processing insights/methods? We'll provide some examples of deep learning methods and want to deepen the scientific discussion towards the extraction of mathematical insights and procedures from deep learning approaches [1].

However, the issue of collecting these signals and presenting them for processing is also one of the actual and important issues. So, usually, people are carried out by specialists who have received special instructions in clinics and hospitals. This is not very suitable for daily activities. Determining asymmetry in time and determining the tendency towards asymmetry is the main idea of the presented article.

More preferable from the perspective of the treating physician would be data collected on a regular basis from daily routine work of the subjects. In such a situation, however, sensors may not be placed properly by the patient and

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movements are not well controlled anymore, so data quality can be compromised. Hence, the validity of the sensor data has to be assessed and taken into account during data analysis in order to derive reasonable conclusions. Therefore, a wearable sensor system for daily life must be multimodal to allow machine learning algorithms to clean the acquired sensor data from artefacts. Artificial intelligence and deep learning system can then identify corrupt data segments, substract artefact patterns and by that clean up sensor data [2].

Classical medical device certification relies on validation processes, in which specific input paramaters lead to defined output varibales. Also a design specification needs to be provided against which the verification and validation is performed. These approaches pose a challenge for AI and Deep Learning systems as it is the nature of theses systems that they are not fully defined and change with growing data sets. Statisitcal methods may help to overcome these challenges. Another example is the increasing use of speech recognition systems which is also entering the medical device arena. While speech recognition shows an high level of ease of use to control devices it also comes with challenges regarding validatitation and certification to ensure the require reliability. These challenges need to be addressed to come up with the required new methods. The goal is to start a discussion around these topics to ensure a smooth translation of ideas on AI and deep learning into daily clinical routine. First answers to these challenges can be found in adjacent areas as well as internationally [3].

The authors of the next paper mainly studied the key parameters in the collected paper: deep-learning model and training architecture, medical tasks, dataset sources, and medical application. These are the essential parameters that influence performance. This paper will also discuss and conclude by highlighting critical research gaps and possible future scope to directly build intelligent computational models from biomedical signals [4].

The generalized information about the possibilities of assessing asymmetry and the prospects of research tools is presented in the next material. The important role of the choice of different methods for processing electromyographic signals, the results of which can be considered as an objective criterion for assessing the asymmetry of the muscles of the extremities, is noted, such as the asymmetry coefficient, a widely used parameter in statistical analysis, which characterizes the asymmetry of the statistical distribution. Also applied is the segmental method of studying the body to obtain estimates of the composition and differences between individual body segments. The isokinetic test method, which makes it possible to assess asymmetry in measuring muscle strength, relies on the randomness of the dynamic processes of the biological system. Use of nonlinear dynamics, the theory of dynamic chaos, and fractal analysis allows for determining the fractal properties of biosignals, and from the classical methods used correlation analysis [5].

In [6], the authors note the importance of new generation technologies and methods in the acquisition and processing of various biomedical signals.

Machine learning can also be applied effectively for the processing and classification of bioelectric signals, like an electrocardiogram (ECG), electroencephalogram (EEG), electromyogram (EMG), etc. Processing of an ECG signal can be categorized into three stages: preprocessing (filtering), feature extraction, and classification. Authors focuses on the application of machine learning–based algorithms at various stages of processing of an ECG signal to extract useful information for early and accurate detection of cardiac disorders in order to provide effective treatment for patients [6].

The research presented in [7] is about of the modeling of the system for diagnosing the asymmetry of the human limb muscles by means of electromyographic signals. The correlation analysis method was chosen for asymmetry assessment. The evaluation, which is first performed using mathematical methods, is then modeled in the Lab View environment. The elements used to create the system are explained in the model. A reporting section containing diagnostic results has been added to the system.

2. Material and methods

LabVIEW software was used to implement the systematic approach. For this purpose, a system has been designed that allows the calculation of correlation coefficients, the determination of asymmetry in selected group muscles using the methods of calculated muscle strength and asymmetry coefficients, as well as which muscle is prone to asymmetry.

Biceps femoris muscle, Gastrocnemius muscle - lateral part, Quadriceps femoris muscle - rectus femoris, Quadriceps femoris muscle - vastus lateralis, Quadriceps femoris muscle - vastus medialis, Gastrocnemius muscle - medial part were taken for the purpose of research.

After the subsystems for the calculation of asymmetry are established, they are combined into a common Asymmetry Diagnostic System (ADS), enabling a systematic analysis.

The system consists of the following information sections:

- Patient’s data.
- Doctor's data.
- Survey method.
- Survey results.
- After Survey Action.

The Survey methods section stores a list of possible studies, after which the system connects to the appropriate subroutine and performs the appropriate calculation (Figure 1).

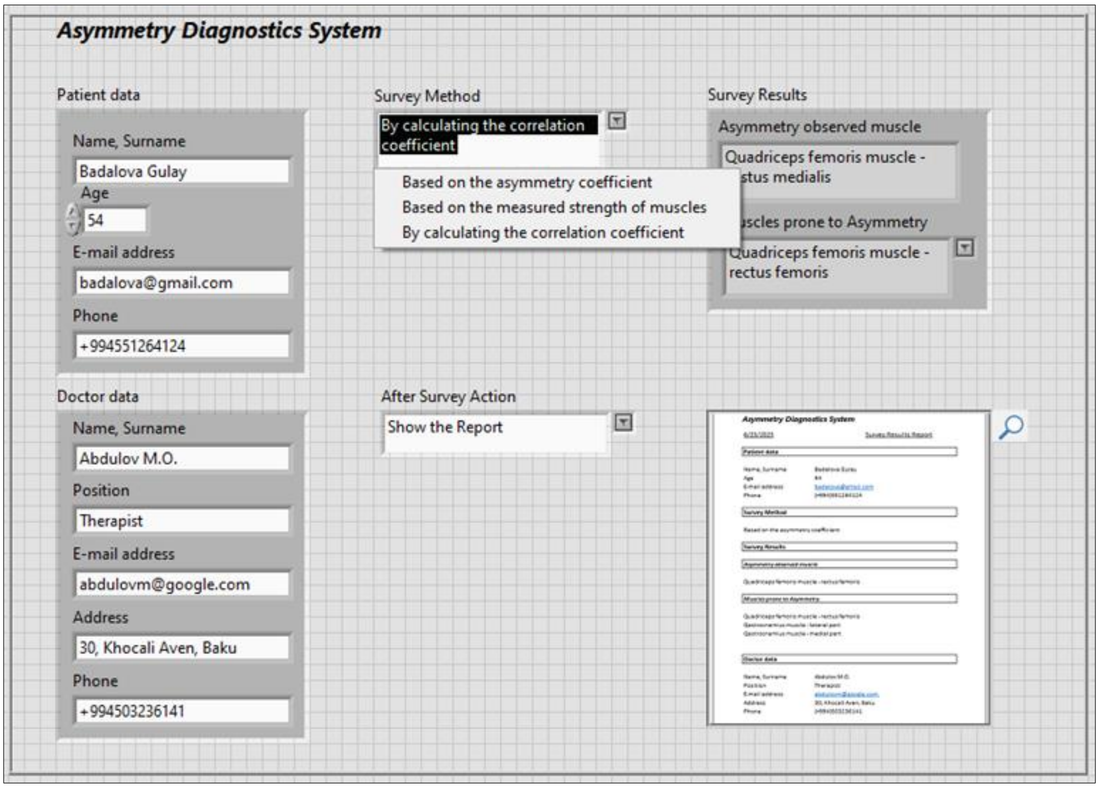


Figure 1 Front panel of ADS and selection of "Survey method" section

The section "Survey results" consists of subsections "Asymmetry observed muscle" and "Muscles prone to Asymmetry". The subsection "Muscles prone to asymmetry" shows three muscles depending on the degree of tendency to asymmetry (Figure 2).

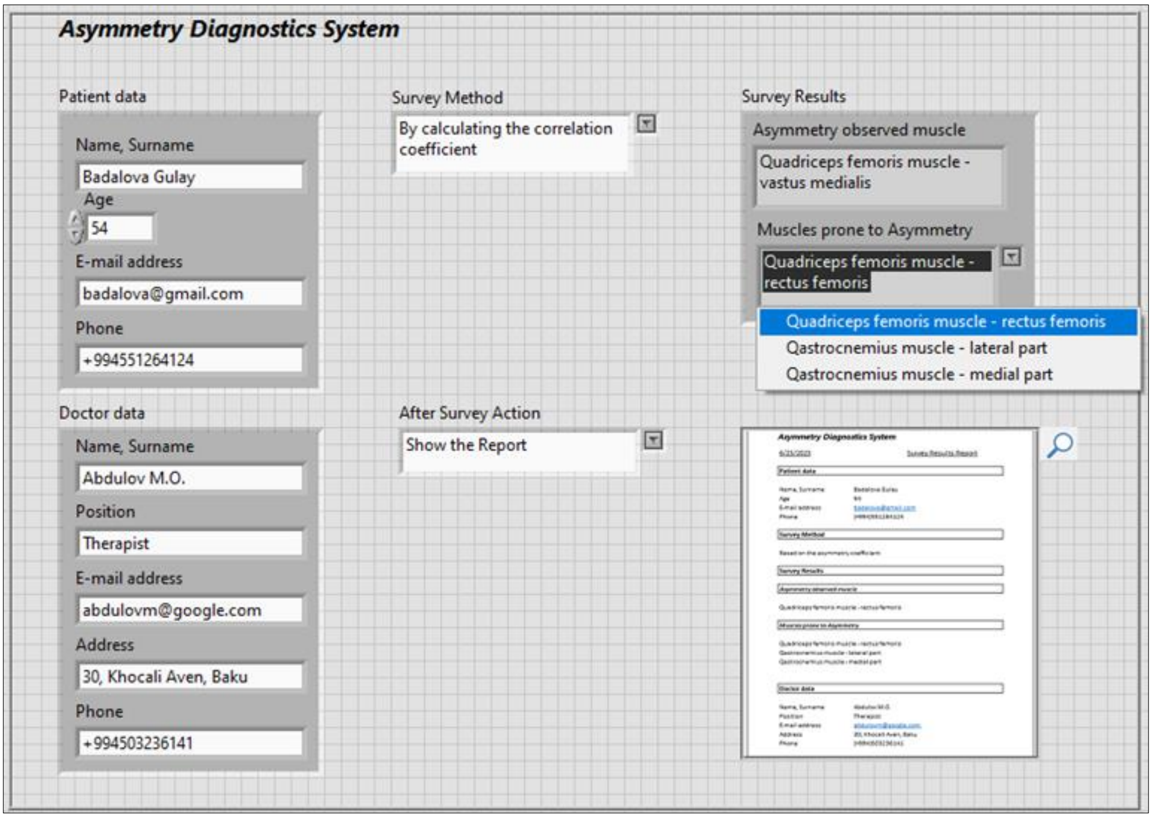


Figure 2 ADS front panel and Survey Results section

The "After Survey Action" section consists the "Show the Report", "Send Report to E-mail" and "Print Report" subsections (Figure 3).

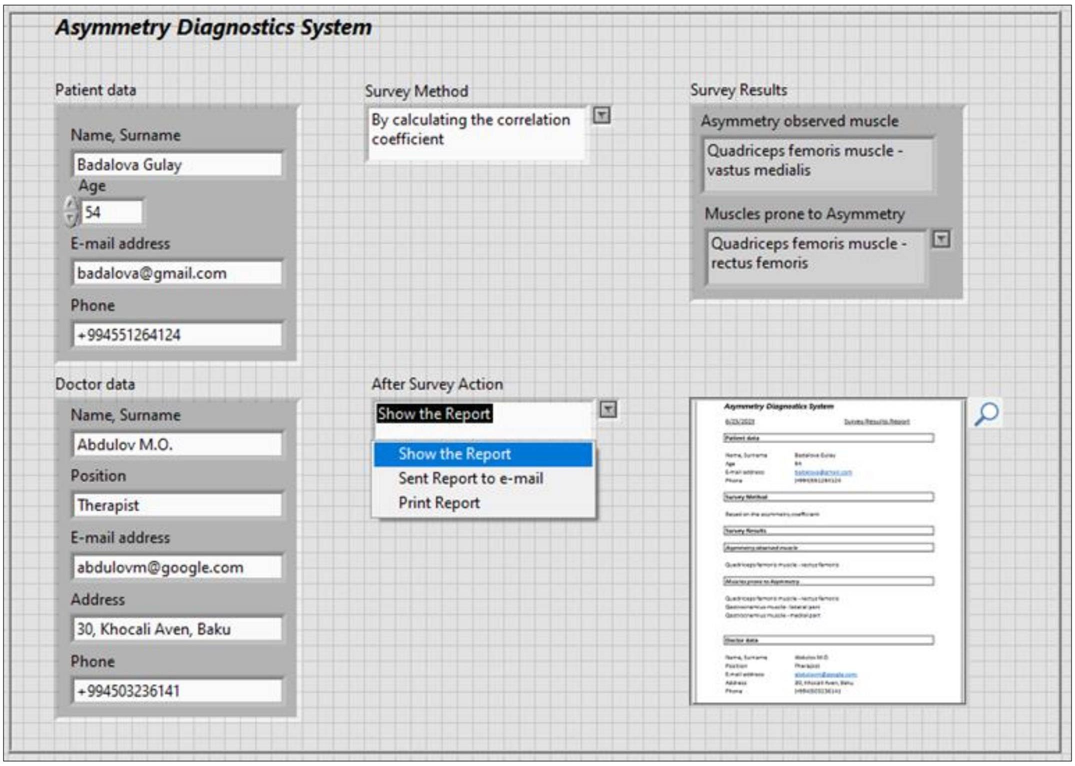


Figure 3 "After Survey Action" section of ADS

The subsection "Show the report" displays the results of the system by transferring them to the Excel program (Figure 4).

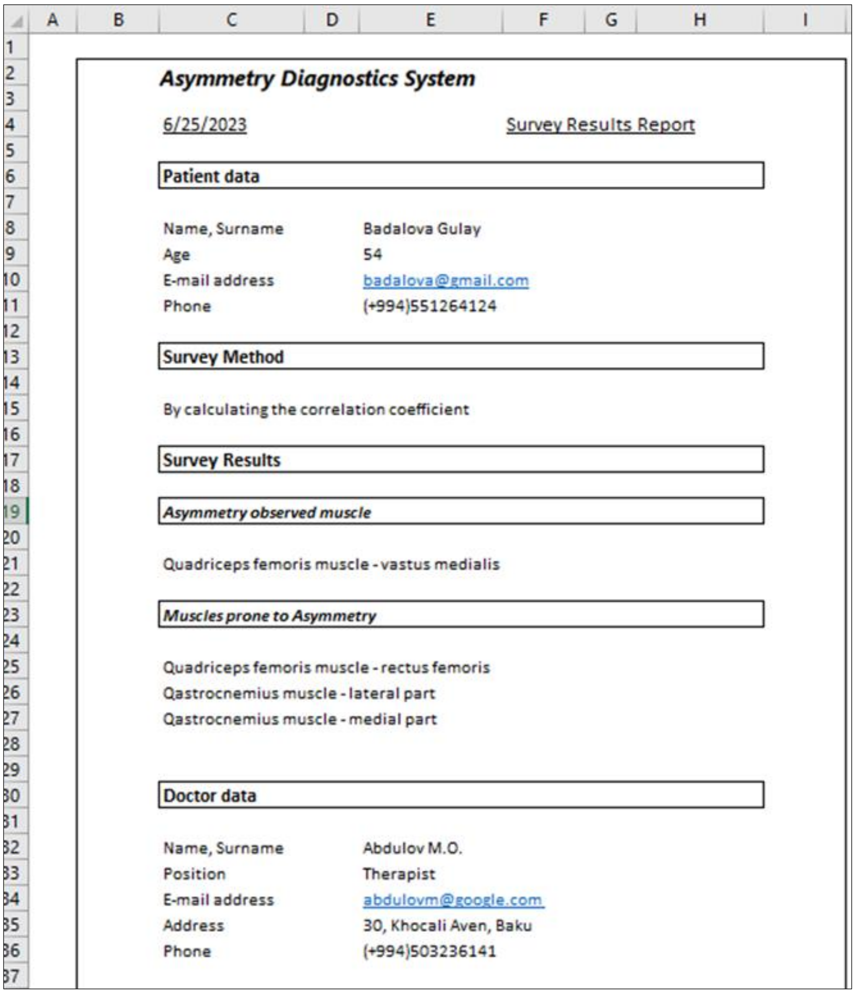


Figure 4 "Show report" subsection of the "After Survey Action" section of the ADS

3. Result and Discussion

In Figure 1-4, the determination of asymmetry by calculating the correlation coefficient was chosen as a research method. As can be seen from the pictures, as a result of the study, the muscle with observed asymmetry - Quadriceps femoris muscle - vastus medialis, and the muscles prone to asymmetry - Quadriceps femoris muscle - rectus femoris, Gastrocnemius muscle - lateral part and Gastrocnemius muscle - medial part were selected.

At the next stage, a method based on the calculation of asymmetry coefficients was chosen as a research method (Figure 5).

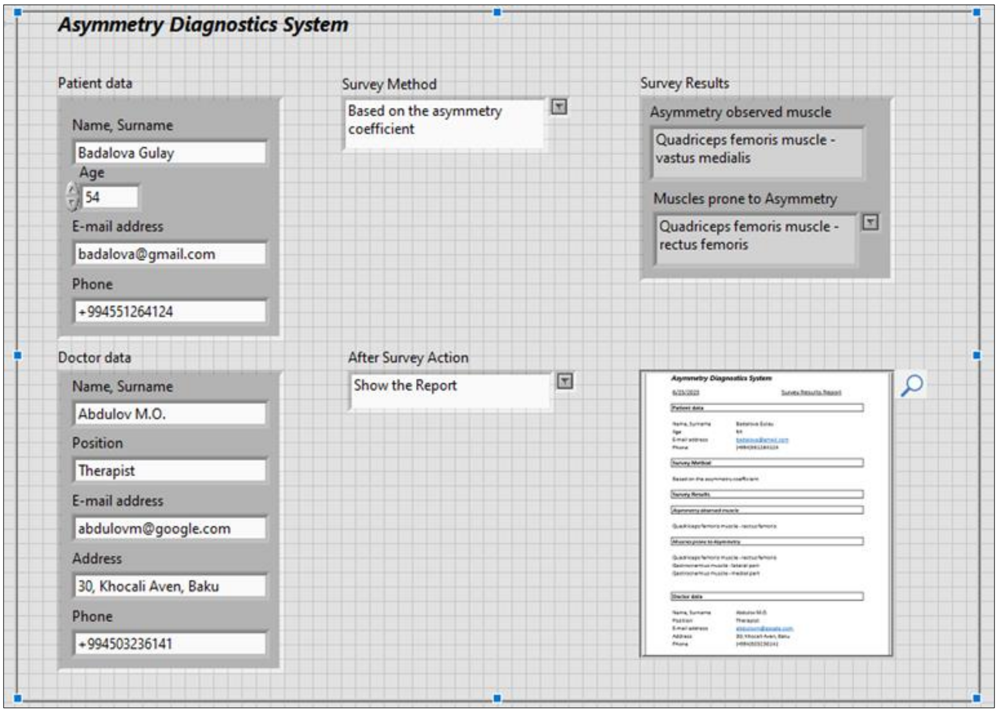
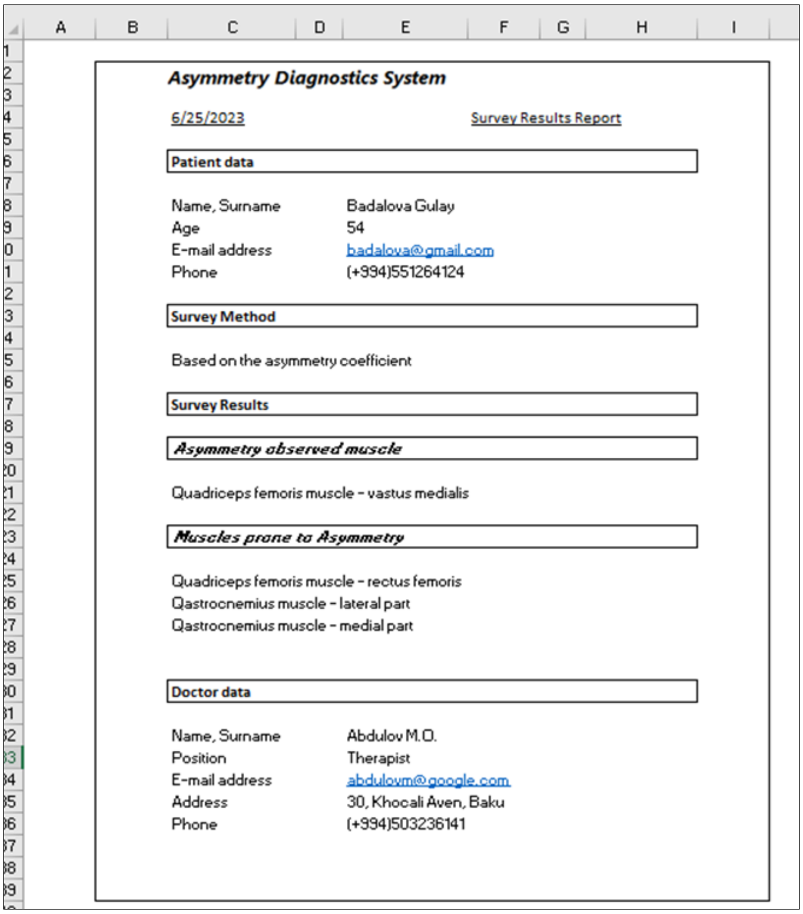


Figure 5 Selection of research method "Based on the asymmetry coefficients".

The report based on the results of the system is shown in figure 6.



Asymmetry Diagnostics System

6/25/2023 Survey Results Report

Patient data

Name, Surname	Badalova Gulay
Age	54
E-mail address	badalova@gmail.com
Phone	(+994)551264124

Survey Method

Based on the asymmetry coefficient

Survey Results

Asymmetry observed muscle

Quadriceps femoris muscle - vastus medialis

Muscles prone to Asymmetry

Quadriceps femoris muscle - rectus femoris
Qastrocnemius muscle - lateral part
Qastrocnemius muscle - medial part

Doctor data

Name, Surname	Abdulov M.O.
Position	Therapist
E-mail address	abdulovm@google.com
Address	30, Khocali Aven, Baku
Phone	(+994)503236141

Figure 6 Report of measurement results

4. Conclusion

It can be seen from both front panel (Figure 5) and the measurement results report (Figure 6) that despite the change in the research method, the diagnostic results were the same. That is, the system can check the use of different methods in the measurements of a patient, and the mentioned approach will allow the doctor to increase confidence in the diagnosis results.

Compliance with ethical standards

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Disclosure of conflict of interest

The author declare that she has no conflict of interest.

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