In search of the unknown…

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The first detection of a gravitational wave in 2015 inaugurated the era of gravitational astronomy. The new window on the Universe that was opened at that very moment allowed us to observe the outer space around us from a completely new perspective. Gravity - the fundamental force in the Universe - has become a valuable source of information on the dynamic processes taking place in space. During violent phenomena such as the merging black holes, neutron stars or supernova explosions, space-time is subject to dramatic changes. The propagating gravitational wave distorts the space it passes through. This effect weakens as the wave propagates away from the source. Although the signal recorded on Earth is negligible (deformations of 10^{-19} m over a distance of 400 km), the gravitational wave emitted during the merging of black holes has a power exceeding the electromagnetic emission of all stars in the observed Universe!

Detection of such subtle phenomena as gravitational waves requires extremely precise equipment. The instruments that enable registration of these signals are laser interferometric detectors built within the Advanced LIGO and Advanced Virgo projects. However, the use of extremely sensitive tools that are able to register gravitational waves does not equal actual detection. This signal is buried deeply in the noise, which at this level is generated practically through everything: the detector itself, human activity such as planes and cars, seismic activity or atmospheric conditions. Therefore, the gravitational wave detection requires the application of a sophisticated analysis of data collected by detectors.

Currently used data analysis methods require detailed knowledge of the shape of the gravitational wave being sought. This is a significant limitation, because our knowledge in this area is incomplete - for example, we do not yet know the exact shape of the wave emitted during a supernova explosion. This limitation is the main reason for the motivation behind the presented project. The titular **unknown** are both gravitational waves whose exact shape we do not know, as well as those known to us whose shape we do not want to assume during analysis. In the presented project, unknown signals are referred to as **anomalies**.

To search for these anomalies, we decided to use **artificial intelligence**, and more specifically **machine learning** algorithms called **deep learning**. An example of such an algorithm are convolutional neural networks which are based on the research of the visual cortex in mammals - the part of the brain that specializes in processing visual information. Widely used in the classification of images or handwriting, they can be invaluable help in searching for subtle anomalies. In the project, we intend to focus not only on gravitational waves, but also on unusual instrumental artifacts that appear in the detector signal imitating gravitational waves. Better understanding and efficient removal of these artifacts from data is key to improving the quality of the signal being studied. And this, in turn, translates into the increased accuracy of the estimation of physical parameters of wave sources - for example, the exact determination of the masses and spins of black holes, which will allow better understanding of their evolution.

In summary, this project aims at exploring the possibilities of using artificial intelligence as an alternative method of searching for gravitational waves regardless of our current knowledge of their shape. As a result, we will significantly expand the possibilities of detecting these signals, and this in turn will translate into a better knowledge of the nature of one of the most dynamic phenomena in the Universe.