Relating deep moonquake source regions from Apollo missions with their temporal and spatial patterns using machine learning

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NASA selected a new in-situ seismic experiment, Farside Seismic Suite (FSS), onboard CP-12 lander with the landing site at the farside of the Moon in Schrödinger Basin. This future mission should provide us with the data to further constrain lunar interior and the Moon seismicity. Due to the single-station nature of the mission, localisation of the newly detected events will be challenging. Therefore, in this study we develop a pipeline for the deep moonquake (DMQ) source region localisation on the legacy of the data acquired during the Apollo missions. We are interested into DMQs since their source regions, called nests, on the near side have been identified, and since their occurrence patterns follow specific spatial and temporal patterns. Spatial patterns are related to tsp=ts-tp travel time measurement. We can show that based on tsp measurements we can form group of nests, called sets, that share similar travel times within error bars and therefore we cannot distinguish between nests that belong to the same set just using the travel time information. Temporal patterns are related to the fact that occurrence of DMQs is closely related to the monthly motion of the Moon around the Earth. Different nests correspond differently to three lunar months: synodic, draconic, anomalistic. By combining the spatial and temporal patterns we try to characterise different nests and exploit this information for their prediction. For this purpose we develop a machine learning model for nets classification. An input data into model we use orbital parameters related to the monthly motion of the Moon around Earth, which we relate to different nests. The ML model is learned to classify between nests that belong to the same set. We report that models are achieving an accuracy over 70% when those are trained to classify =< 4 nests within the set, and better than 90% when only two DMQ nests are in the same set. This approach opens up a new way to DMQ location estimate, on the near and farside of the Moon, when captured by the future FSS single-station seismometers or other seismic stations on the Moon.