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Optimal correction of data from misoriented multi-component geophysical sensors

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One of the most important problems affecting geophysical data acquisition procedures is related to the misorientation of multi-component sensors with respect to a common reference system. Misoriented sensors affect data analysis procedures, which can lead to errors in results and interpretations. These problems generally occur in applications in which the orientation of the sensor cannot be actively controlled and is not known a priori. Common examples are geophysical sensors deployed in borehole installations or on the seafloor. In this presentation we introduce two methods to optimally correct data sets from misaligned sensors.

Firstly, we consider two-component time-series data. These commonly result from the assumption that the vertical axis of a three-component sensor is correctly determined, and therefore the data from that respective component can be excluded from the correction process. This is a common approach and it is used in many applications. We show that the optimal misalignment-correction for such a two-component data set can be estimated in a single, non-iterative calculation step (c.f. Grigoli et al., 2012). The result is optimal with respect to the l_2 norm of the overall deviation between the re-oriented and the optimal data. We demonstrate the functionality of our method by applying it to synthetic and real data examples (seismic data; Vertical seismic profile, Ocean bottom seismometers, Seismological array).

Although the simplification of neglecting the third sensor component is commonly applied, and the resulting deviations are assumed to be negligible, it is still beneficial to take the full information contained in the data sets into account. Therefore, we have developed a reorientation algorithm for multi-component geophysical sensors (i.e. two- and three-component sensors). In the second part of this presentation, we introduce this quaternion-based method, which yields an analytical solution for the (relative) reorientation of sensors in three dimensions. We show that our method is not only fully functional, but also that it is superior to the commonly applied approach of a grid search over the parameter space for finding optimal rotation paramters (c.f. Krieger & Grigoli, 2015). We also demonstrate that the assumption a potential deviation of the vertical sensor component from the true vertical only leads to small errors in the result is not necessarily true. Hence, we conclude that it is important to rely on an analytical estimate of reorientation paramters, and that the inclusion of all sensor components in the process of this estimation is important. By introducing our new approach to the correction of sensor mis-alignment, we can overcome the dependency on approximative solutions and eliminate systematic sources of errors in standard time-series data processing.

References:

Grigoli, F., Cesca, S., Dahm, T., Krieger, L. (2012); *A complex linear least-squares method to derive relative and absolute orientations of seismic sensors*; Geophysical Journal International; 188(3); 1243-1254.

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