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Automatic jump detection in time transfer link for the calculation of UTC

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Coordinated Universal Time (UTC) [1] is calculated as a weighted average of about 420 atomic clocks located in 80 laboratories spread word-wide. All the clocks participating are compared each other by using time transfer links. Currently UTC makes use of GNSS (MC, P3 or PPP) and TWSTFT time transfer techniques as can be seen in Section 5 of Circular T [2]. In this paper a new algorithm is developed to improve the reliability of UTC. The new algorithm is based on the Kalman filter routine. The Kalman filter is used in many fields because of its ability to clean data from white phase noise. In this paper in particular the use of Kalman Filter as tool to detect time and frequency steps in the time links (GNSS or TWSTFT) used in UTC calculation is presented.

Considering that UTC is not computed in real time we adapt and optimize the detection algorithm presented in [3] by applying the filter forwards and backwards in time; these filtered data are then combined after stopping both series at the date of the step. Applying these Kalman filters we obtain the results reported in Fig. 1 where the black line shows the original data, the green and the blue lines the filter forwards and backward respectively. Finally the red line shows the combination of both. It is clear from the zoomed figure that the combined solution gives a more correct information concerning the value of the step. With the described method we detect a phase jump at 59480.3115 MJD. This data corresponds perfectly to the information needed by the BIPM. The clear advantage to use both filters is for the evaluation of the value of the step because even if by using only one filter the phase noise is smoothed out very well the value of the jump is not perfectly catched. If we stop the filters forwards and backwards at the date of the step and we combine them the final solution this allows a better evaluation of the step. To apply the detector based on the Kalman filter an important part of the work is the evaluation of the parameters as the white and frequency noises presents in the data. This method represents a novelty with respect to the detector presented in previous publications and will be tested and generalized to have an automatic procedure.

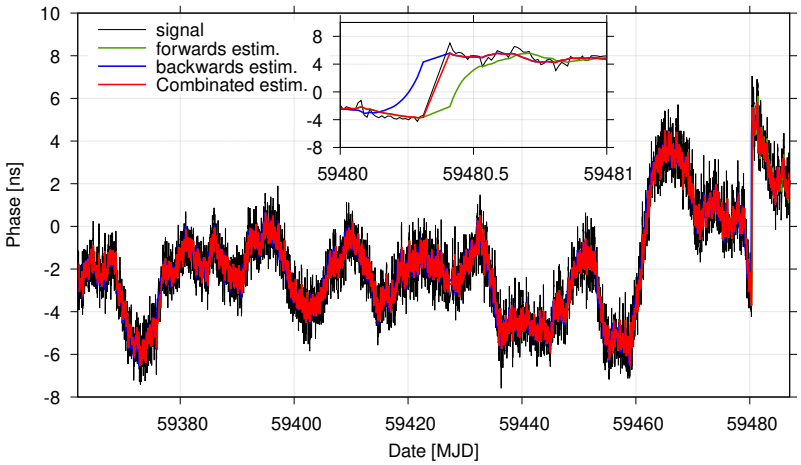

Figure 1. Detection of a time step in the phase data. The time deviation of the time link signal (in black) is filtered by the Kalman procedure(in red).

References

[1] G. Panfilo and F. Arias, The Coordinated Universal Time (UTC), *Metrologia*, **56**, 4, 2019, 042001

[2] https://www.bipm.org/en/time-ftp/circular-t

[3] L. Galleani and P. Tavella, "Detection of atomic clock frequency jumps with the Kalman filter," *IEEE TUFFC*, **59**, 3, March 2012, pp. 504-509, doi: 10.1109/TUFFC.2012.2221.