4. CONCLUSION

This paper presented the application of probabilistic tracking techniques for tracking small space debris, with a focus on addressing the Too Short Arc problem. The optical and radar admissible regions, and the associated apsis constraints were derived. The uniform distribution of the admissible region is fit with a Gaussian mixture model, which serves to initialize an unscented Kalman filter. The methodology extends previous efforts by introducing GMM splitting and pruning, which significantly improved the filter's performance and reduced degeneracy when applied to real-world data. The final output of the GMM-UKF represents the probability density function of potential orbital states. Fisher's distinctness measure is then used to determine if two GMMs overlap and represent the same object. The product between the two GMMs is then used to define the overlapping region, which is collapsed to a single Gaussian PDF. The single Gaussian can then be used for more accurate state estimation via traditional batch filters. This approach offers a robust and effective solution for the tracking of small debris, and is currently being applied to real optical and radar data collects as part of the SINTRA program.

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