Contribution ID: **46** Type: **Oral**

3-D Rain Rate Estimation from Integrated Measurements of Commercial Wireless and Satellite Links

Wednesday, June 26, 2019 3:10 PM (20 minutes)

Abstract

In the last decade, various algorithms have been developed to provide accurate rainfall maps from measurements of rain-induced attenuation on commercial wireless links (CWLs), such as [1].
These solutions provide precise results but they also require dense terrestrial microwave networks, which have non negligible installation and operating costs.
A cheaper alternative for rainfall estimation is represented by broadcast satellites links (BSLs).
However, to the best of authors' knowledge, these approaches are able to estimate the rainfall rate on a single point only [2]-[4].
To gain all the benefits provided by both the cited schemes, we propose an adaptation of the state-of-the-art algorithm in [1] which is able to integrate the data provided by both the CWLs and BSLs, yielding a three-dimensional (3-D) rain rate map of a monitored area.
Our contribution lies in the technical description of the data processing schemes developed to retrieve these maps, with particular interest in the 3-D system model.
In the following, we summary the machinery of our approach. Let us consider a monitored zone, where $N = N_w + N_s$ communication links are active, with N_w and N_s are the number of CWLs and BSLs, respectively. It is worth noting that rain is assumed only present below the 0°C isotherm height. We divide then the vertical dimension into H fixed heights, from ground level up to the 0°C isotherm height. Hence, by implementing the algorithm in [1] for each height, we obtain a set of H rain maps, one for each height value, yielding to a 3-D description of the phenomena.

The effectiveness of novel approach is assessed using a simulator able to set up a configuration of the coordinates for both CWL and BSL terminals, and an instance of a simulated rain in a randomly-generated position. Preliminary results are given in Figures 1 and 2 (presented into the attached file) which illustrate different scenarios in the presence of the same rain conditions. In the scenario of Fig. 1, the estimation is performed using only 21 CWLs, while Fig. 2 presents the estimation results using 13 BSLs and 8 CWLs. Though the position of the rain column with diameter 3 km is correctly estimated in both cases, it can be nevertheless noted that the joint utilization of both CWL and BSL provides a more accurate estimation of the rain intensity.
To show a more general prove of effectiveness, the near-to-the-ground RMSE between actual and estimated rain rate is plotted for different scenarios. In Fig. 3, the RMSE is shown as a function of the number of wireless links, randomly chosen from the arrangement presented in Fig. 1. The curves are plotted for different numbers of satellite receivers, i.e., 0, 4, 8 and 16 randomly-positioned on the maps. It is apparent that even a few number of satellites can be of great help in reducing the RMSE.

Acknowledgement

This work is supported by Fondo per le Agevolazioni alla Ricerca and Fondo Aree Sottoutilizzate (FAR-FAS) 2014 of the Tuscany Region, Italy, under agreement No. 4421.02102014.072000064 SVI.I.C.T.PRECIP. (Sviluppo di piattaforma tecnologica integrata per il controllo e la trasmissione informatica di dati sui campi precipitativi in tempo reale).
Fruitful discussions with prof. Hagit Messer of the University of Tel Aviv are greatly acknowledged.

References

[1] O. Goldshtein, H. Messer, and A. Zinevich, “Rain rate estimation using measurements from commercial telecommunications links,” *Signal Processing, IEEE Transactions on*, vol. 57, pp. 1616 – 1625, 05 2009.
[2] F. Giannetti, R. Reggiannini, M. Moretti, E. Adirosi, L. Baldini, L. Facheris, A. Antonini, S. Melani, G. Bacci, A. Petrolino, and A. Vaccaro, “Real-time rain rate evaluation via satellite downlink signal attenuation measurement,” *Sensors*, vol. 17, p. 1864, 08 2017.
[3] F. Giannetti, M. Moretti, R. Reggiannini, and A. Vaccaro, “The NEFOCAST system for detection and estimation of rainfall fields by the opportunistic use of broadcast satellite signals,” *Aerospace and Electronic Systems, IEEE Magazine*, 2019.
[4] A. Gharanjik, K. V. Mishra, B. S. Mysore, and B. Ottersten, “Learning-based rainfall estimation via communication satellite links,” 06 2018, pp.

Authors: SAGGESE, Fabio (University of Pisa); Prof. GIANNETTI, Filippo (University of Pisa); Prof. LOTTICI, Vincenzo (University of Pisa)

Presenter: SAGGESE, Fabio (University of Pisa)

Session Classification: Specific research topics

Track Classification: Specific HyMet CML research topics (presentations on Day2, posters on Day1)