RADIO BASE NETWORK AND TOMOGRAPHIC PROCESSING FOR REAL TIME ESTIMATION OF THE RAINFALL RATE FIELDS

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High density radio base station networks for mobile communication systems (i.e. GSM, GPRS, UMTS) are nowadays available, especially in populated urban areas and along the major roads and communication routes. Such radio networks encompass a high number of microwave radio links of different lengths (from hundreds of meters to dozens of kilometers), depending on the relative disposition of the radio base stations.

Rainfall generally attenuates the power of the microwave signals: such attenuation depends on the frequency of the signal carrier and on rainfall through well established power law K-R relationships relating the specific attenuation per unit length at a given frequency to the local rainfall intensity [1]. The total attenuation along a microwave communication link is obtained by integrating such relationships along the radio path, and is therefore related to the average rainfall along the link. When the microwave links intersect, forming a sort of web, we get a tomographic network whose power attenuation measurements can be processed by *ad hoc* tomographic algorithms, providing a scalar field of specific attenuation that can be immediately converted in a scalar rainfall rate field using the aforementioned K-R relationships.

Some years ago, we developed and presented some tomographic algorithms that can be applied to generic measurement networks for different remote sensing applications (see [2],[3],[4] and [5]). Specifically, the first of these applications was exactly rainfall rate estimation using a sparse microwave network [2].

In this paper, we propose a novel remote sensing method that is adequate for rainfall rate measurements in real time by means of tomographic processing applied to power attenuation measurements made across the microwave links defined by radio base station networks for mobile communication systems. The importance of this approach for rainfall monitoring is self-evident, since it would allow to provide high-density rainfall estimates exploiting an existing infrastructure for measurements with a very limited additional cost.

We present some simulation results of rainfall rate estimation applying our tomographic algorithms [2], [4] and [5] to the current radio base station configuration over the city of Florence, Italy. We simulated the attenuation measurements along the microwave radiolinks by using true weather radar absolute reflectivity (Z_H) maps to which we applied Z_H-K relationships [1]. The Z_H radar maps are converted in rainfall rate maps using the Z_H-R relationships and then converted to specific attenuation maps using the K-R relationships. The specific attenuation maps are then used to simulate the power attenuation measurements along the true microwave radiolink network.

We made several simulations using different rainfall events and different radiolink network topologies to test the reconstruction performance of the rainfall fields. We found out that the number of possible microwave radiolinks (considering all the radio base stations in Florence, independently of the telephone company) is much higher than the number of links that is generally sufficient to provide a good estimate of the rainfall field. This implies that the radiolink number, that generally is available in a radio base network of a mobile communication system for a medium-size urban area like that of the city of Florence, is certainly sufficient for a rainfall measurement system based on the tomographic processing method proposed here.

The overall results show that the proposed method offers a very firm and solid way to estimate rainfall rate, in real time and with high spatial resolution, using tomographic processing with power attenuation measurements among the radiolinks of radio base station networks of mobile communication systems.

The proposed approach could be used to monitor the rainfall rate over critical areas - like dense urban areas or strict valleys crossed by busy motorways - that are generally characterized by the presence of dense radio base networks but often not (completely) visible by other remote sensing systems such as weather radars that, though more expensive, are limited by orography: in fact, the choice of a radar site in orographically complex areas is often the result of a difficult compromise among different requirements, while the distributed approach of the tomographic network has not this kind of drawback.

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