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Review

Positioning Methods and the Use of Location and Activity Data in Forests

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Abstract: In this paper, we provide an overview of positioning systems for moving resources in forest and fire management and review the related literature. Emphasis is placed on the accuracy and range of different localization and location-sharing methods, particularly in forested environments and in the absence of conventional cellular or internet connectivity. We then conduct a second review of literature and concepts related to several emerging, broad themes in data science, including the terms *location-based services (LBS)*, *geofences*, *wearable technology*, *activity recognition*, *mesh networking*, *the Internet of Things (IoT)*, and *big data.* Our objective in this second review is to inform how these broader concepts, with implications for networking and analytics, may help to advance natural resource management and science in the future. Based on methods, themes, and concepts that arose in our systematic reviews, we then augmented the paper with additional literature from wildlife and fisheries management, as well as concepts from video object detection, relative positioning, and inventory-tracking that are also used as forms of localization. Based on our reviews of positioning technologies and emerging data science themes, we present a hierarchical model for collecting and sharing data in forest and fire management, and more broadly in the field of natural resources. The model reflects tradeoffs in range and bandwidth when recording, processing, and communicating large quantities of data in time and space to support resource management, science, and public safety in remote areas. In the hierarchical approach, wearable devices and other sensors typically transmit data at short distances using Bluetooth, Bluetooth Low Energy (BLE), or ANT wireless, and smartphones and tablets serve as intermediate data collection and processing hubs for information that can be subsequently transmitted using radio networking systems or satellite communication. Data with greater spatial and temporal complexity is typically processed incrementally at lower tiers, then fused and summarized at higher levels of incident command or resource management. Lastly, we outline several priority areas for future research to advance big data analytics in natural resources.

Keywords: Global Positioning System; Global Navigation Satellite System; radio frequency identification; ultra-wideband; radio telemetry; passive integrated transponder; big data; Internet of Things; location-based services; activity recognition; wearable technology; mesh network; geofence; forestry; wildland fire; fisheries; wildlife

1. Introduction

In this paper, we describe and review literature on several technologies and estimation methods that can be used to determine and communicate the position, navigation, and timing (PNT) of moving