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A Prototype of an Integrated Telemetry Receiving System with Volunteers: Designs of a Simple Receiver, a Protocol, and an Intelligent Information Processing

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Abstract

In this paper, we propose “social diversity” which is an integrated satellite telemetry receiving system with volunteers. In the proposed system, a number of volunteer receivers catch the satellite signals with a simplified cheap receiver, instead of using a comprehensive and expensive antenna receiving station. Although such signals may contain various errors or may be lost, the intelligent information techniques can compensate such signals by using a number of simultaneously received signals and profiled data. For the purpose of the whole system developments, we tackle mainly three issues. Firstly, we develop a simple receiver for the amateur bands radio waves. Secondly, we design the receiving data format for the transfer and server-client web receiving system. Finally, we thrash out suitable intelligent information techniques for our system. Here we report a development status of our whole satellite telemetry system. Especially, this report focuses on the simple SDR (Software-Defined Radio) receiver for the voluntary observers and a prototype of the web system for collecting a number of satellite telemetry data and compensating the incomplete telemetry data.

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1. Introduction

This study aims to construct an integrated satellite telemetry receiving system with volunteers. The volunteers support a part of the proposed system’s operation by providing the received telemetry data. In the proposed system, an intelligent information processing plays an important role to compensate errors of signals transmitted by the satellites. The authors also develop a simplified receiver to receive the telemetry signals. The proposed simple receiver is used for the novice volunteers. This paper reports a development progress of the proposed system and the simple receiver. This paper also demonstrates the typical example of the telemetry receiving with the test website of the proposed system.

The authors propose a new concept to construct the integrated telemetry system, “social diversity”. The diversity scheme is a method for improving the reliability of the signals in radio communications. For example, spatial diversity. In the spatial diversity, the signals are received by the multiple antennas that are physically separated from one another. The social diversity is a voluntary-based scheme, which is categorized into one of the cooperative diversities. The concept of the social diversity involves not only the voluntary telemetry receiving but also the intelligent information processing. In the social diversity, this paper defines that the word “social” represents various kinds of receivers, which involves not only automatic telemetry receivers but also man-operated receivers.

However, the social diversity differs from usual reception systems. That is the dynamical system itself because the structure of the voluntary observation network changes dynamically. Further, this paper refers to the social diversity system as an information system. The development project of the social diversity tackles with the construction of the integrated telemetry receiving system to support satellite operations teams.

In the proposed system, the telemetry data received from the satellites are submitted to a repository server. On the repository server, a web application for the social diversity runs and provides the service for visitors of the website. The web application in the server-side processes the telemetry data by the intelligent information processing. In the intelligent information processing, the web application profiles the telemetry data, and it makes relations based on the features of the data. The web application in the server-side compensates the incomplete parts in the telemetry data, because the telemetry data may contain a number of errors. The proposed system depends on the huge amount of the data collected by the volunteers. Therefore, the proposed system needs to collect the telemetry data by a contribution of the volunteers.

This study deals with the following three issues: (1) The information system for the social diversity, (2) The simple receiver for the volunteers, and (3) The Intelligent information processing techniques for the incomplete telemetry data. In the first issue, this project develops the information system to construct the web application for the social diversity. In the second issue, the authors develop the simple receiver for the volunteers because the social diversity requires the many ground stations for compensating the errors contained in the telemetry data. The project supports a number of volunteers by providing technical documents on building the simple receiver. The technical documents stimulate the volunteers such as they build their own simple receivers. In the third issue, the authors choose a different approach compared with the former projects. The social diversity involves not only the collaborative diversity scheme but also the intelligent information processing. The social diversity system compensates the incomplete data to improve the availability of the data. Our intelligent information processing techniques incorporate the daily or the long-term variations (e.g., daily variations of the status of the satellites) to compensate the incomplete telemetry data.

In recent years, universities, colleges of technology (referred as KOSENO, that is a distinctive educational system in Japan), and venture companies develop and launch CubeSats of miniaturized satellites in the world. The satellite operations teams need to monitor and understand the status of the satellites by gathering the telemetry data. Usually, the telemetry data contain not only a working status of the satellites themselves (referred as housekeeping data) but also observation data (referred as mission data). The satellite operation teams develop the telemetry receiving systems as well as the satellites. They attempt to collect the telemetry data with much effort. The contribution of the volunteers supports to collect the telemetry data in the satellite operations teams.

The telemetry data transmitted by the satellites possibly contains the errors due to some technical reasons (Fig. 1). These three technical issues are as follows: (1) A Doppler shift between a satellite and a ground station, (2) jamming by unlicensed radio stations, and (3) a signal attenuation by an atmospheric attenuation. These three issues change information originated from the telemetry data transmitted by the satellites. The CubeSats mainly use amateur radio bands for communication. To solve these three issues, actually, the volunteers in the world receive the telemetry...
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