A Ground-Based Synthetic Aperture Radar System Using Portable VNA for Landslide Monitoring

Yohandri
Physics Department
Faculty of Mathematics and Natural Science, Universitas Negeri Padang
Jl. Hamka, Air Tawar, Padang, West Sumatera, Indonesia
yohandri.unp@gmail.com

Bambang Setiadi
Research Center for Geotechnology
Lembaga Ilmu Pengetahuan Indonesia (LIPI)
Kompleks LIPI Bandung, Indonesia
bambang.setiadi@lipi.go.id

Yee Kit Chan and Voon Chet Koo
Faculty of Engineering & Technology
Multimedia University
Jalan Ayer Keroh Lama, Bukit Beruang, Melaka, Malaysia

Abstract*— Landslide monitoring is crucial for early detection of landslide hazard and reduce the risk of a landslide. In this work, a Ground-Based Synthetic Aperture Radar (GB-SAR) system intended for landslide monitoring has been developed. The system is used to cognize a point target located at a certain distance. This GB-SAR system consists of portable VNA module, SAR processor, stepper controller, linear guide, and horn antenna. A portable VNA module is employed as transmitter and receiver of the signal based on the reflection coefficient (S11) principle. The laboratory experiment is done to verify the system performance to detect the point target. Result of laboratory experiments is highlighted and discussed in this paper.

Keywords— ***GB-SAR, VNA, Landslide, laboratory experiments***

I. INTRODUCTION

Indonesia has a relatively high intensity of natural disasters due to the geographical location. In addition, Indonesia has a lot of mountains and hills that are prone to landslide disasters. The position of Indonesia in the tropics has a high level of rainfall, which can be trigger the landslide. In 2015, there are about 350 of landslide occurrences in Indonesia. In West Sumatra meanwhile, there were 39 occurrences of landslides [1]. These disastrous events from year to year has increased and caused a lot of victims and material losses. Based on this situation, an early detection of landslides system is required to monitor the ground motion continuously.

The use of radar technology in the landslide has been done to measure the area of disaster impact and magnitude of displacement of the ground after the disaster [2]. This technology will only have an impact on policy in the future and cannot avoid the occurrence of casualties or damages from the disaster itself. In addition, the radar data come from satellite cannot be recorded the potential areas of landslides continuously. Therefore, Ground-Based Synthetic Aperture Radar (GB-SAR) is appropriate to be implemented as early detection of potential disasters in areas vulnerable to landslides.

In principle, the GB-SAR uses the same technique with Satellite or UAV-Based SAR. In UAV based SAR, the radiation of the antenna is transmitted in side-looking direction to the Ground [3]. In GB-SAR system, the antenna radiation is delivered tilted towards the target area. Data on the GB-SAR obtained by movement radar within a few kilometers of the area that became the target [4][5][6]. Observations of the target area can be done at any time of day or night without depending on weather conditions. Data from GB-SAR measurements can be processed into images that can provide information about the movements of the ground. Based on this principle, the early warning system of the landslides can be developed.

In previous research [7], the study of GB-SAR for the early detection of landslides has been conducted and important parameter in designing a system of GB-SAR is calculated. In this work, the GB-SAR system intended for the early detection of landslides is constructed.

II. GROUND-BASED SAR SYSTEM

The major parts of the GB-SAR system are composed of a Vector Network Analyzer (VNA) module, SAR processor, stepper controller and horn antennas. Fig. 1 presents the block diagram of the GB-SAR system. A VNA module has a port and can be operated up to 5 GHz. The SAR processor is built

978-1-5386-0465-6/17/$31.00 ©2017 IEEE

using a mini personal computer (PC). This processor will control the transmitting and receiving signal of the VNA as well as control the horn antenna movement. The movement of the antenna is regulated using stepper motor based on the program in the mini PC. The backscattered signal from point targets are captured in the same antenna such as the measurement of the reflection coefficient (S11). The measured data is recorded on the storage media inside the PC. The movement of the antenna on a linear slide is performed by a stepper motor under control the stepper controller. Step of the movement can be configured using software on the PC and monitored on the display.

III. Result and Discussion

Fig. 2 shows the received power plotted as a function of distance. In the experiment setup, a corner reflector is placed around of 4.3 m in front of the antenna. Based on this graph, the position of a corner reflector can be detected and measured by the system. On the other hand, the SAR image of 100 point target is generated as presented in Fig. 3. In the range direction, the distance of the object consistent with the result as presented in Fig. 2.

IV. Conclusion

A GB-SAR system intended for landslide monitoring has been developed and presented in this paper. The laboratory experiment has successfully been performed. The GB-SAR system has shown good performance in terms of real and imaginary data. A SAR image has been processed and presented the good agreement with the point target. The result of laboratory experiment shown the performance of the GB-SAR system mostly satisfies the requirements for landslide monitoring. In the future work, the accuracy of the system to detect the small movement of the target will be investigated and field test also will be performed.

Acknowledgment

The authors would like to thank Directorate General of Higher Education (DIKTI), Ministry of Research, Technology and Higher Education, Indonesia, for the Research Grant (INSINAS 2016), Grant number 336/UN35.2/PG/2016.

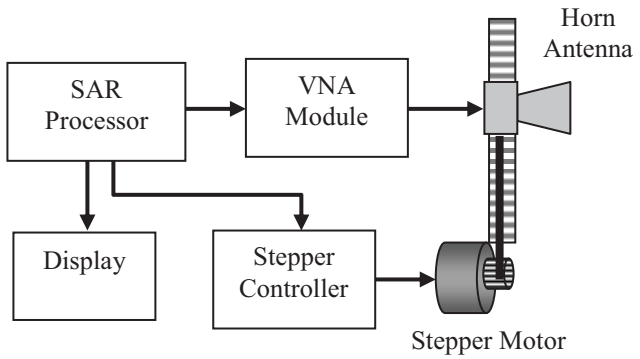

Fig. 1 Block diagram of GB-SAR system

References

[1] The National Disaster Management Agency (BNPB), Indonesian Disaster Data and Information http://dibi.bnpb.go.id/data-bencana/lihat-data, accessed on 28 September 2015

[2] T. Strozzi, P. Farina, A. Corsini, C. Ambrosi, M. Th¨uring, J. Zilger, A. Wiesmann, U.Wegm¨uller, C. Werner, “Survey Andmonitoring of Landslide Displacements Bymeans of L-Band Satellite SAR Interferometry”, DOI: 10.1007/s10346-005-0003-2, Springer-Verlag 2005.

[3] Yohandri, Asrizal and J. T. S. Sumantyo, "Design of tilted beam circularly polarized antenna for CP-SAR sensor onboard UAV," 2016 International Symposium on Antennas and Propagation (ISAP), Okinawa, 2016, pp. 658-659.

[4] G. Antonello, N. Casagli, P. Farina, D. Leva, G. Nico, A.J. Sieber and D. Tarchi, “Ground-based SAR interferometry for monitoring mass movements”. Landslides, 1(1): 21-28, 2004.

[5] B. Massimo, C. Alessandro, C. Nicola, F. Paolo, C. Franco, S. Paolo, L. Davide, and T. Dario, “Space-Borne And Ground-Based SAR Interferometry For Landslide Activity Analysis And Monitoring In The Apennines of Emilia Romagna (Italy)”: Review Of Methods And Preliminary Results, Proc. of FRINGE 2003 Workshop, Frascati, Italy, 1 – 5 December 2003

[6] F. Bozzano, P. Mazzanti and A. Prestininzi, “A Radar Platform for Continuous Monitoring of A Landslide Interacting with An Under-Construction Infrastructure”, Italian Journal of Engineering Geology and Environment, pp. 35-50, 2008.

[7] F. Diana and Yohandri, “Modeling of Ground Based Synthetic Aperture Radar (GB-SAR) System for Early Detection of the Landslide” , Pillar of Physics, Vol. 7, pp. 17-24, April 2016

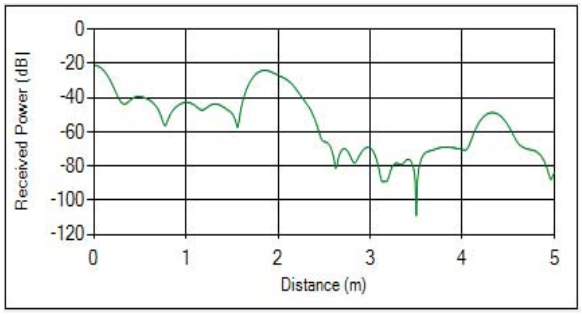

Fig. 2 Received power plotted as a function of distance

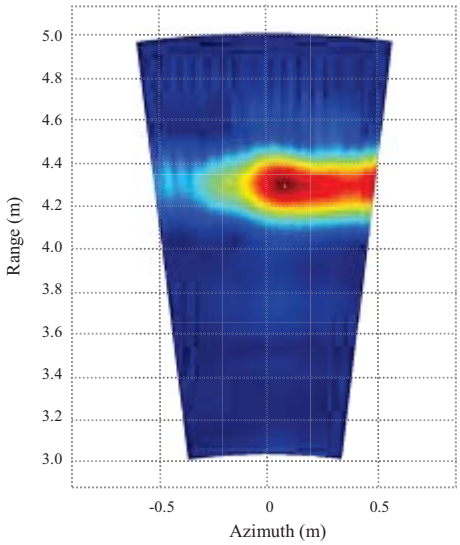

Fig. 3 SAR image of the target point