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論 文

RADARSAT SAR와 KOMPSAT EOC에 의한 선박 탐지의 검증: 현장 실험

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Validation of Ship Detection by the RADARSAT Synthetic Aperture Radar and KOMPSAT EOC: Field Experiments

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요 약 : 두 개의 다른 위성 센서 (RADARSAT SAR와 KOMPSAT EOC)를 사용하여 선박탐지 실험을 실시하였으며, 탐지성능을 검토하였다. 목포항과 울산항을 대상으로 실시하였으며 필요에 따라 현장 검증 데이터를 얻기 위하여 위성 통과 시에 선박에 승선하여 선박정보를 포함하는 Sea Truth를 취득하였다. 또한 VTS 레이더 정보를 위성데이터와 비교를 통하여 위치정보의 검증을 수행하였다. 광학과 마이크로파 원격탐사에 있어 그 특성의 차이는 뚜렷하였으나, 광학의 경우 선속 3.1kts 이상인 선박의 후류가 탐지되었으며, 마이크로파의 경우, 최대 6-7kts의 선박에 대해서도 후류의 탐지는 어려웠다. 그러나, 마이크로파는 다양한 선형을 반영한 신호가 sigma nought로 표현되므로 향후 선형 정보뿐만 아니라, 침로의 추출이 가능하다는 결론을 얻었다. 또한, 동일 선박이라 할지라도 신호강도의 차이에 의해 선박이 2개 이상으로 나타나는 현상도 파악되었다. 앞으로 다양한 해상환경 및 위성 관측 모드에 따른 추가 실험을 실시하여 자동 선박추출이 가능할 것으로 판단된다.

핵심용어 : RADARSAT위성, 合成開口레이더, KOMPSAT, 선박탐지

ABSTRACT : *Two different sensors (here, KOMPSAT and RADARSAT) are considered for ship detection, and are used to delineate the detection performance for their data. The experiments are set for coastal regions of Mokpo Port and Ulsan Port and field experiments on board pilot boat are conducted to collect in situ ship validation information such as ship type and length. This paper introduce mainly the experiment result of ship detection by both RADARSAT SAR imagery and land-based RADAR data, operated by the local Authority of South Korea, so called vessel traffic system (VTS) radar. Fine imagery of Ulsan Port was acquired on June 19, 2004 and in-situ data such as wind speed and direction, taking pictures of ships and natural features were obtained aboard a pilot ship. North winds, with a maximum speed of 3.1 m/s were recorded. Ship's position, size and shape and natural features of breakwaters, oil pipeline and alongside ship were compared using SAR and VTS. It is shown that KOMPSAT/EOC has a good performance in the detection of a moving ship at a speed of 7 kts or more an hour that ship and its wake can be imaged. The detection capability of RADARSAT doesn't matter how fast ship is running and depends on a ship itself, e.g. its material, length and type. Our results indicate that SAR can be applicable to automated ship detection for a VTS and SAR combination service.*

KEY WORDS : RADARSAT, SAR, KOMPSAT, Ship Detection

1. Introduction

With the increasing importance in monitoring ship traffic in both coastal and ocean waters, an automatic detection of ships, wakes, and ship velocity is very de-sirable. By using land-based radar, Vessel Traffic Ser-vice (VTS) has been developed and applied in water-ways around ports. The control of ships near coasts is currently supported by VTS radar but it is restricted be-cause of available information limitations. In addition to that, the coverage of monitoring ships by the traditional VTS is limited to the bay area or the approach from the sea to a harbour. There is a requirement for improving the VTS to be able to cover areas where radar coverage is almost impossible to achieve.

Yang and Park (2003) suggested an approach merg-ing of satellite remote sensing and environmental stress model to ensure marine safety for the navigational wa-ters off the radar range.

As shown in Fig. 1, optical sensor such as KOMP-SAT/ECO with a high spatial resolution can image clearly ship and its wake, but it is difficult to separate the two data individually. Figure 2 shows an overlay image of ship and wake area extracted from KOMPSAT data on the PTMS radar information. The acquisition time is different to each other by 5 seconds because PTMS backup data is updated every 20 seconds. Ship informa-tion tracked by the PTMS during the data acquisition are listed in Table 1. In the comparison of KOMPSAT with PTMS radar, two ships (the Mi Ra, the Gwang Sun 2) was not detected in the image and the Sam Yang 7 of 81 m long and 14.5 m across appeared as a bright dot KOMPSAT/EOC has a good performance in the de-tection of a moving ship at a speed of 7 kts or more an hour that ship and its wake can be imaged.

RADARSAT has the capability to detect both station-ary and moving ships on the ocean. Ships are good mi-crowave reflectors, or hard targets, in a sense acting as radar corner reflectors. They return a large portion of the incident energy back to the SAR sensor and may appear in the SAR imagery as relatively bright points or elon-gated bright blobs. Due to this strong hard target behav-ior, the location of fishing fleets can be easily deter-mined using SAR imagery. Successful SAR detection of ships depends, nevertheless, on the size and type of ves-sel, the prevailing wind speed conditions, the SAR reso-lution used and the viewing angle [Vachon et al. (1997), Morse and Protheroe (1997), Wackerman (1996)].

A VTS and SAR combination service, therefore, could be an alternative proposal to expand vessel-monitoring coverage to ocean waters. The objective of this paper is to present the results of field experiment in detecting ships using RADARSAT-1/SAR File mode. VTS-radar data was used

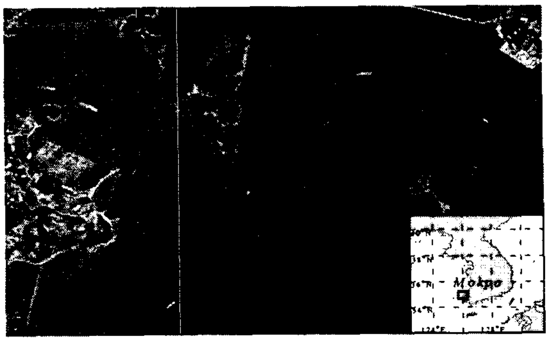

Fig. 1 KOMPSAT/EOC subimage, Mokpo SoutheastCoast of South Korea, March 21, 2003. The right-bottom figure represents the Korean Peninsula and Mokpo area.

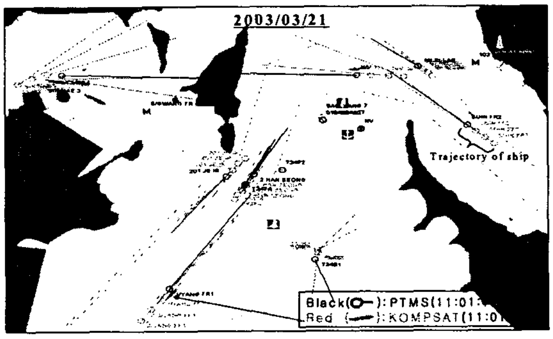

Fig. 2 Overlay image of ship and wake area extracted from KOMPSAT data on the PTMS radar information. The acquisition time is different to each other by 5 seconds because PTMS backup data is updated every 20 seconds.

Table 1 Ship Information tracked by the PTMS during the data acquisition as shown in Figure 1.

No	Ship name	Breadth	Length	Status
1	Jae Il 201	5.8m	22m	on a voyage (moving)
2	Han Sung 2	4.5m	25m	on a voyage
3	Jin San 2	3.6m	15m	on a voyage
4	Hae Sin 3	4.0m	14m	on a voyage
5	Mi Ra	3.0m	10m	on a voyage
6	Sam Yang 7	14.5m	81m	at anchor (stationary ot stop)
7	Gwang Sun 2	2.5m	12m	at anchor

to validate the ship position obtained from SAR imagery and ship size and type, the inci-dence angle, and the sea state such as wind speed and wave height, in-situ data were measured and pictures of ships were taken aboard a ship.

2. Data

2.1 SAR Image Data: Fine Mode

The SAR aboard RADARSAT-1 operates in the C-band and with horizontal transmit and horizontal receive polarization (C-HH). SAR images cover a swath width of about 45 km and have an across-track spatial resolu-tion of about 9m. This instrument can produce images in seven different modes and with multiple viewing angles ranging from 10° to 59°. RADARSAT-1 is sun-synchronous satellite operating in near polar orbit at alti-tudes of about 800 km. In the case of ship detection, the probability of detection is enhanced at large incidence angles (Vachon et al., 1996).

RADARSAT-1 satellite SAR data acquired on June 19, 2004 and processed at the Korea Earth Observation Cen-ter (KEOC) as shown in Fig. 3. The Fine mode is proc-essed to the path image plus level (SGX) with 3.125m pixel spacing (F2) and the incidence angle is 41.2 °. SAR image is calibrated to geophysical (sigma-naught) values of radar cross section (RCS) even if data numbers (DN) on these detected images can be viewed as indicating relative radar backscatter intensities.

2.2 Wind and Ship Information: VTS

Wind and radar data were acquired at Hwaamchu site and transmitted to VTS center (PTMS in Fig. 4). The line in Fig. 4 shows a trajectory moved aboard a pilot ship as shown in Fig. 5. VTS refers to the services pro-moting effectiveness improvement in port operation and reduction in distribution cost by providing counsel or required information for safe vessel service within the range of not violating rights or exempting obligations of the shipmaster via observing movement of vessels in port area and entrance routes with the latest scientific devices of radar, CCTV and

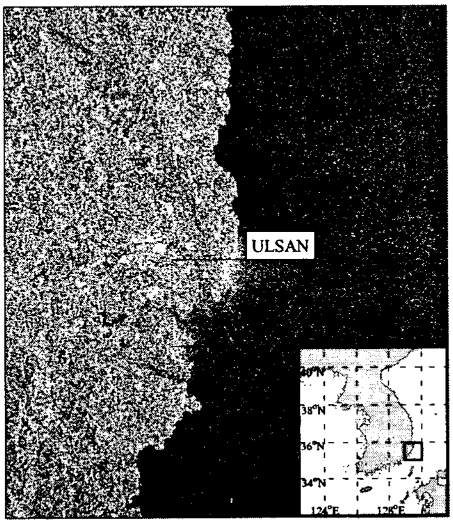

Fig. 3 RADARSAT image, Ulsan Baycentered East Coast of South Korea, June 19, 2004.

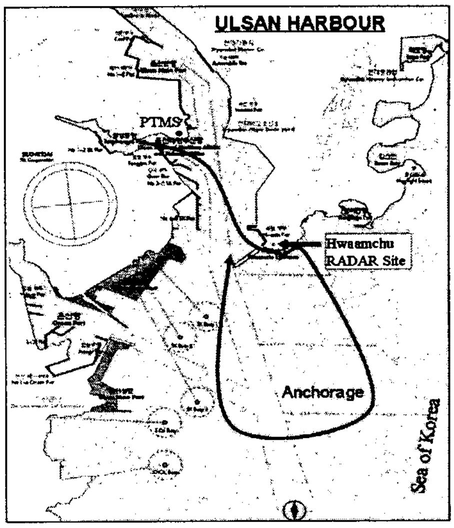

Fig. 4 Map of Ulsan Bay. Radar and weather data were measured at Hwaamchu site. The bold line represents a trajectory of ship used here.

Fig. 5 Ship used during the field experiment.

VHF, etc. for the purpose of increasing vessel safety and effectiveness as well as of protecting environment.

During the field experiment, northwest winds, with speeds from 2.6 m/s to 3.2 m/s were recorded with 0.5 m significant wave height. VTS tracks most shipping traffic using shore-based radar. VTS data are available at twelve-second intervals and consist of a vessel code (ship name, position, speed, course and speed) on a map. The code can be used to ascertain ship length, breadth, depth, and type, and the VTS display can be overlaid with radar images of ships.

A pilot ship was going around at Ulsan anchorage under the RADARSAT pass and boarded taking photos of ships along theline as shown in Fig. 4.

3. Ship Detection Results

The vessels tracked by the VTS and pictured aboard a pilot ship are listed in Table 1. Figure 4 represents VTS-Radar (X band) based ship locations and Fig. 5 shows RADARSAT Fine mode image calibratedto sigma naught. Vessels at anchorage No. 1 and No.2 as shown in Fig. 4

are identified in SAR image (Fig.5). Breakwater (B.W. in Fig. 4) is also not seen in the image, but the two lighthouses at each end of the breakwater appear as a bright dot. In addition, the pilot boat of length 14 m made of FRP was detected by the Fine mode image but was not apparent. The fine line between detected or not detected is likely related to vessel type, vessel course relative to SAR look-direction, or vessel material. For example, the Hanyang Ace, a petroleum product tanker has a scattered radar reflection property and then is represented by several parts of potential ship pixels in the SAR

Table 2 Ship Information tracked by the PTMS during the data acquisition as shown in Figure 1.

Ship Name	Ship Code	Length(m)	Breadth(m)	Depth(m)	Type of ship
Hanyang Ace	HACE	78	13	7	Petroleum Product Tanker
Pacific Sambu	PSAM	84	14	8	Chemical Tanker
De Da	DEDA	90	16	8	Towing Tug
Alpha Gas	AL/G	93	16	7	Liquefied Gas(LPG) Tanker
Sea Line	SEAL	70	12	6	General Cargo Ship
Supertec	SUPT	185	32	16	General Cargo Ship
Hae Nam	HAEN	60	10	5	Petroleum Product Tanker
ASIAN DYNASTY	AS/D	193	32	20	Car Carrier
BUNGA KELANA 3	*Alongside*	236	42	21	Oil Tanker

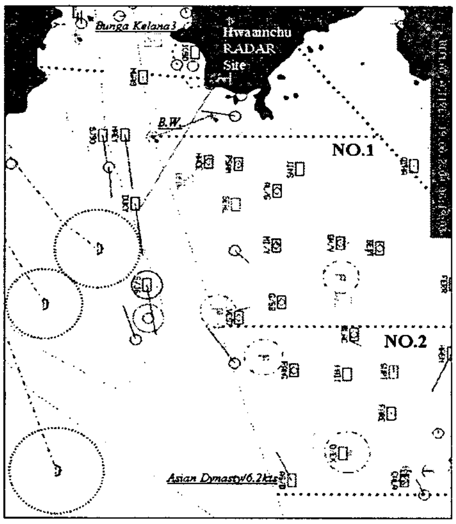

Fig. 6 VTS-Radar based ship locations and codes. NO.1 and 2 are anchorages.

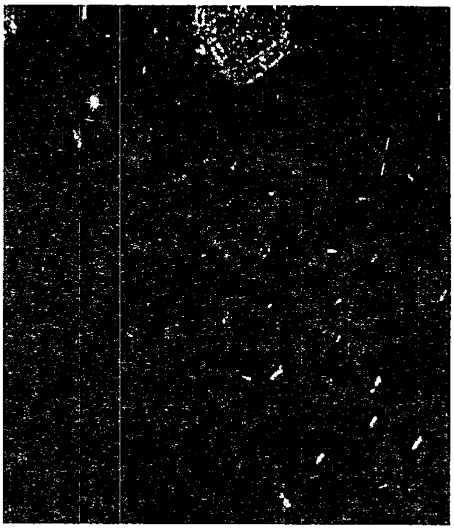

Fig. 7 RADARSAT Fine mode image calibrated to sigma naught.

data. The Haenam at the right-bottom of Fig. 4 was identified by the RADARSAT but because there was a discrepancy between the VTS Radar location and the real ship location as revealed in VTS radar images(here omitted).

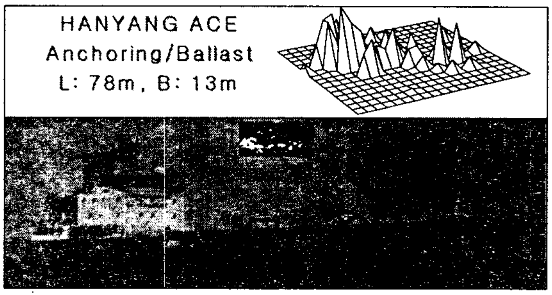

Fig. 8 Vessel classification by RADARSAT Fine mode image: Petroleum Product Tanker. Upper left represents a vessel information for the photo in the bottom, and top-right figure is a contour plot for a beta nought.

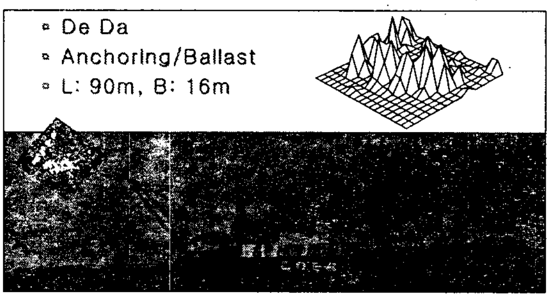

Fig. 9 Vessel classification by RADARSAT Fine mode image: Towing Tug. Upper left represents a vessel information for the photo in the bottom, and top-right figure is a contour plot for a beta nought.

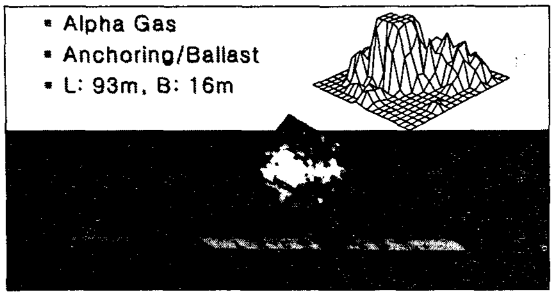

Fig. 10 Vessel classification by RADARSAT Fine mode image: LPG Gas Tanker. Upper left represents a vessel information for the photo in the bottom, and top-right figure is a contour plot for a beta nought.

There was no evidence of ship wakes, but ship detection rate for merchant vessels is almost 100 % in this experiment.

4. Concluding Remarks

Two different sensors (here, KOMPSAT and RADARSAT) are considered for ship detection, and are used to delineate the detection performance for their data. The experiments are set for coastal regions of Mokpo Port and Ulsan Port and field experiments on board pilot boat are conducted to collect in situ ship validation information such as ship type and length. This paper introduce mainly the experiment result of ship detection by satellite images and land-based RADAR data, operated by the local Authority of South Korea, so called vessel traffic system (VTS) radar. It is shown that KOMPSAT/EOC has a good performance in the detection of a moving ship at a speed of 7 kts or more an hour that ship and its wake can be imaged. The detection capability of RADARSAT doesn't matter how fastship is running and depends on a ship itself, e.g. its material, length and type. Our results indicate that SAR can be applicable to automated ship detection for a VTS and SAR combination service.

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