The 3rd UN World Conference on Disaster Risk Reduction in Sendai
PUBLIC FORUM
第三回国連防災世界会議フォーラム

Fast Estimation of the disaster debris for immediate recovery from the disaster
被災からの早期復旧へ向けた高速な災害廃棄物量推定

Forum Abstract
フォーラム概要

Laboratory of Multidisciplinary Research on the Circulation of Waste Resources, Sendaikankyo Co. Endowed Lab, Graduate School of Environmental Studies, Tohoku University
東北大学大学院環境科学研究科・資源循環複合新領域
(仙台環境開発株式会社寄付講座)

Mar 15, 2015, Sendai Civic Auditorium, Meeting room 1,
2015 年 3 月 15 日 9:00~11:00　仙台市市民会館会議室 1

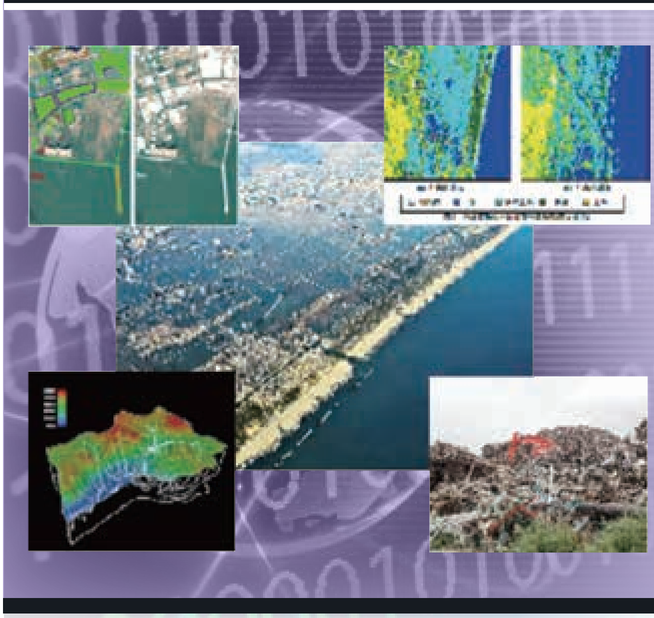
The 3rd UN World Conference on Disaster Risk Reduction in Sendai
PUBLIC FORUM

Analysis of aerial photographs and satellite images for the estimation of mega-disaster waste in devastated areas

– Laboratory of Multidisciplinary Research on the Circulation of Waste Resources, Sendaikankyo Co. Endowed Lab, Graduate School of Environmental Studies, Tohoku University–

15 MAR 2015
9:00〜11:00

Sendai Civic Auditorium, Cofference Room No.1
4-1, Sakuragaoka Koen, Aoba-ku, Sendai.
Tel 022-262-4721



Forum abstract

Areas devastated by mega-disasters suffer from severe damages of their infrastructures. Lack of information prevents fast reconstruction of the affected areas. The analysis of aerial photographs and satellite images can be employed to gather information of the affected areas necessary for their reconstruction. The results can be widely used for planning the tasks required for recovery such as scheduling the waste removal and the business recovery process for companies, etc. The aim of this forum is to introduce our effort to detect the damaged building and to estimate the amount of disaster debris (waste) by using aerial photographs and by satellite images, and to discuss the future perspective of applying the results to disaster waste transport planning and water resource management system.

Programme

9:00	Opening
9:10〜9:15	**Opening Address** Azuma Ohuchi Professor, Graduate School of Environmental Studies, Tohoku University
9:15〜9:35	**Analysis of Remote Sensing Data to Estimate Amount of Disaster Waste** Yoichi Kageyama Professor, Graduate School of Engineering and Resource Science, Akita University
9:35〜10:05	**Estimation Amount of Disaster Debris by Analyzing the Aerial Images** Masahito Yamamoto Professor, Graduate School of Information Science and Technology, Hokkaido University
10:05〜10:25	**Issues of Disaster Waste Transport Planning** Kunihiro Kishi Associate Professor, Graduate School of Engineering, Hokkaido University
10:25〜10:45	**Building of Water Resource Management System with Integrated Water Cycling Simulation** Hiroshi Yamamura Assistant Professor, Faculty of Science and Engineering, Department of Integrated Science and Engineering for Sustainable Society, Chuo University
10:45	Closing

SENDAIKANKYOKAIHATSU CO., LTD. UN World Conference on Disaster Risk Reduction 2015 Sendai Japan TOHOKU UNIVERSITY

Analysis of aerial photographs and satellite images for the estimation of mega-disaster waste in devastated areas

Date: 9:00–11:00, March 15, 2015

Venue: Sendai Civic Auditorium Meeting room1, 4-1, Sakuragaoka Koen, Aoba-Ku, Sendai

Programme

9:00～ 9:10 Opening

9:10～ 9:15 Opening Address

Azuma Ohuchi (Professor, Graduate School of Environmental Studies, Tohoku University)

9:15～ 9:35 Analysis of Remote Sensing Data to Estimate Amount of Disaster Waste

Yoichi Kageyama (Professor, Graduate School of Engineering and Resource Science, Akita University)

9:35～10:05 Estimation Amount of Disaster Debris by Analyzing the Aerial Images

Masahito Yamamoto (Professor, Graduate School of Information Science and Technology, Hokkaido University)

10:05～10:25 Issues of Disaster Waste Transport Planning

Kunihiro Kishi (Associate Professor, Graduate School of Engineering, Hokkaido University)

10:25～10:45 Building of Water Resource Management System with Integrated Water Cycling Simulation

Hiroshi Yamamura (Assistant Professor, Faculty of Science and Engineering, Department of Integrated Science and Engineering for Sustainable Society, Chuo University)

10:45 Closing

Analysis of aerial photographs and satellite images for the estimation of mega-disaster waste in devastated areas

Opening address

Azuma Ohuchi

Professor of Laboratory of Multidisciplinary Research on the Circulation of Waste Resources, (Sendaikankyo Co. Endowed Lab, Graduate School of Environmental Studies, Tohoku University)

Abstract:

Areas devastated by mega-disasters suffer from severe damages of their infrastructures. Lack of information prevents fast reconstruction of the affected areas. The analysis of aerial photographs and satellite images can be employed to gather information of the affected areas necessary for their reconstruction. The results can be widely used for planning the tasks required for recovery such as scheduling the waste removal and the business recovery process for companies, etc. The aim of this forum is to introduce our effort to detect the damaged building and to estimate the amount of disaster debris (waste) by using aerial photographs and by satellite images, and to discuss the future perspective of applying the results to disaster waste transport planning and water resource management system.

Photograph after the disaster (Asia Air Survey Co. Ltd)

Classification results by remote sensing

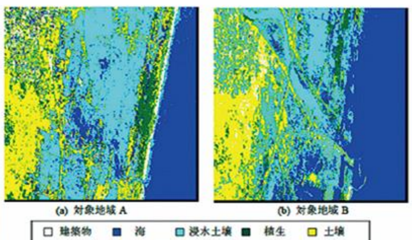


図5　分解画像の土地被覆分類結果(図4対応)

Destroyed area detection from serial images

Analysis of aerial photographs and satellite images for the estimation of mega-disaster waste in devastated areas

Analysis of Remote Sensing Data to Estimate Amount of Disaster Waste

Yoichi Kageyama

Professor, Graduate School of Engineering and Resource Science, Akita University

Abstract:

When a large-scale disaster occurs such as the East Japan Great Earthquake, there is a need to estimate the amount of disaster wastes promptly and to perform subsequent restoration activities quickly and effectively [1]. We are sure that a disaster waste estimation using remote sensing data is the first priority to affect all subsequent processing. However, the digital number (DN) of each pixel represents the average land cover conditions. That is, the information provided by a pixel should be represented as one-pixel mix-class instead of one-pixel one-class. This pixel is referred to as a mixel [2]; both mixels and pure pixels should be considered in order to accurately classify land cover conditions. It is also necessary to develop a method for extracting detailed information buried in mixels of remote sensing data. Therefore, the aim of this talk is to introduce a method for unmixing mixels that uses the DNs and texture features appeared in remote sensing data [3].

The coastal area in Miyagi Prefecture, Japan was selected as the study area, and Thailand Earth Observation System (THEOS) data acquired on March 14, 2011 was used for analysis. The ground sample of the THEOS is 15 m for bands 1 through 4.

Fig.1 shows the flowchart of data analysis. First, five classes— Buildings, Sea, Flooded soil, Vegetation and Soil — were set and then forty pixels were extracted per class as the supervised data. Second, the multispectral bands provided an estimate of the occupancies in a pixel by fuzzy reasoning [2]. Third, pure pixels and mixels were classified using the DNs and the texture. When the class occupancy, obtained by the DNs, of any pure class except "Flooded soil" class wasn't less than the threshold T_1, the pixel was classified into the class that was characterized by the largest value. Subsequently, if the class occupancy of the "Flooded soil", obtained by the texture, wasn't less than the threshold T_2, the pixel was classified as the pure pixel of the "Flooded soil". Pixels not classified in the

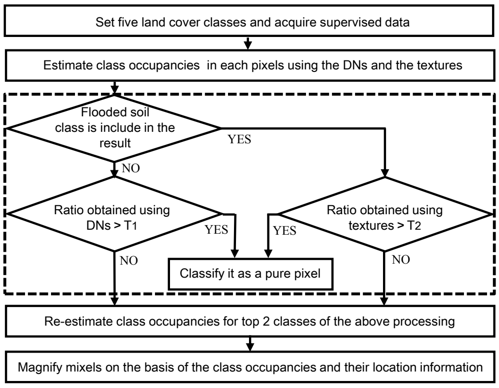


Fig.1 Flowchart of data analysis.

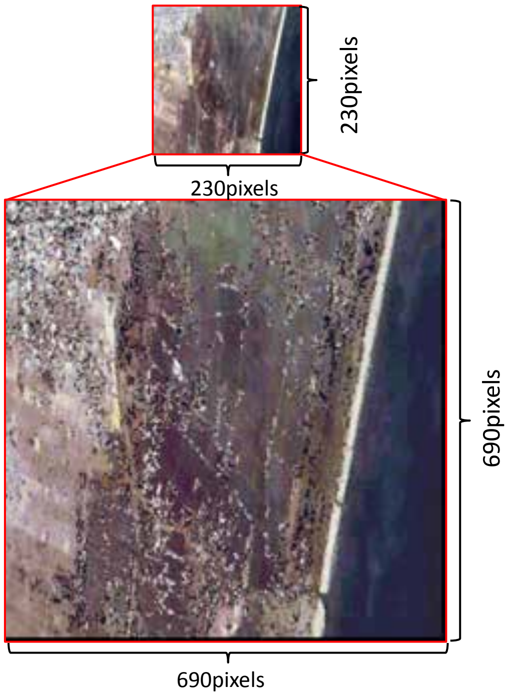


Fig.2 Magnification result.

above-mentioned process were mixels. Fourth, for the mixels, class occupancies for top 2 classes were re-estimated using textures. Finally, mixels were magnified on the basis of the class occupancies and their location information.

Fig.2 shows a magnification result. One pixel in the original image is divided into nine pixels by the proposed method; all the pixels of the magnification result are expressed as

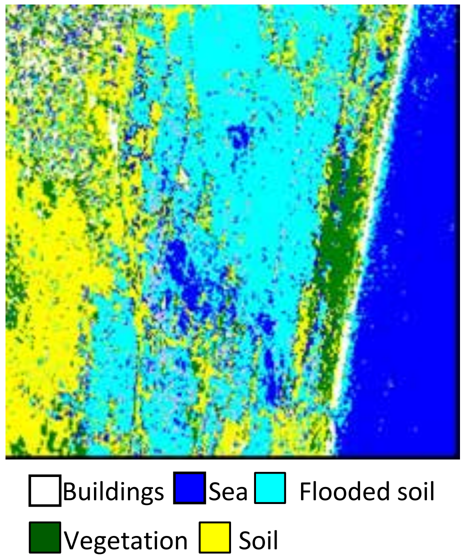


Fig.3 Classification result.

pure pixels, although the original image consists of the mixels and pure pixels. Therefore, the boundaries of the classes and the land cover conditions are clear. Fig.3 shows the classification result. The proposed method is in good agreement with the manually classified map; the matching rate of the proposed method is 90.44%. The result suggests that the proposed approach using mixels provides reasonable results.

References

[1]T. Takaya, S. Sato, A. Ohuchi, "Con sideration about the amount presumption system of disaster wastes learned from the East Japan Great Earthquake", The 74th, National Convention of IPSJ, 3B-4 (2012).

[2]M. Nishida, K. Otsuka, R. Tabata, "Estimation of Class Mixture Proportion of Mixel due to Fuzzy Reasoning," Trans. IEE Japan, Vol.116-C, pp.359-366 (1996).

[3]Y. Kageyama, K. Hisa, A. Ohuchi, T. Takaya, M. Nishida, "Method for unmixing mixels of THEOS data to estimate amount of disaster waste", Journal of Japan Society for Fuzzy Theory and Intelligent Informatics, Vol.26, No.2 (in press).

Tohoku University DRR Actions
Contributing to Global Disaster Resilience

Analysis of aerial photographs and satellite images for the estimation of mega–disaster waste in devastated areas

Analysis of Remote Sensing Data to Estimate Amount of Disaster Waste

Yoichi Kageyama
Professor, Graduate School of Engineering and Resource Science,
Akita University

Akita University

2015.03.15

東北大学は第3回国連防災世界会議を支援しています。

Motivation

- Recovery and reconstruction plan learned from the East Japan Great Earthquake

  A need to estimate the amount of disaster wastes promptly and to perform subsequent restoration activities quickly and effectively

- Remote Sensing

  Remote sensing refers to the activities of sensing objects or events at far away places without making physical contact.

Estimate the amount of disaster wastes
↓
Install temporary places
└ Prepare machines and workers
↓
Install primary dumps
└ Processing method and system
↓
Estimate treatment costs and period

Flowchart of disaster wastes disposal plan †

† T. Takaya, S. Sato, A. Ohuchi, "Consideration about the amount presumption system of disaster wastes learned from the East Japan Great Earthquake",The 74th, National Convention of IPSJ, 3B-4 (2012).

Purpose

Develop a estimation method of amount of disaster wastes by remote sensing data

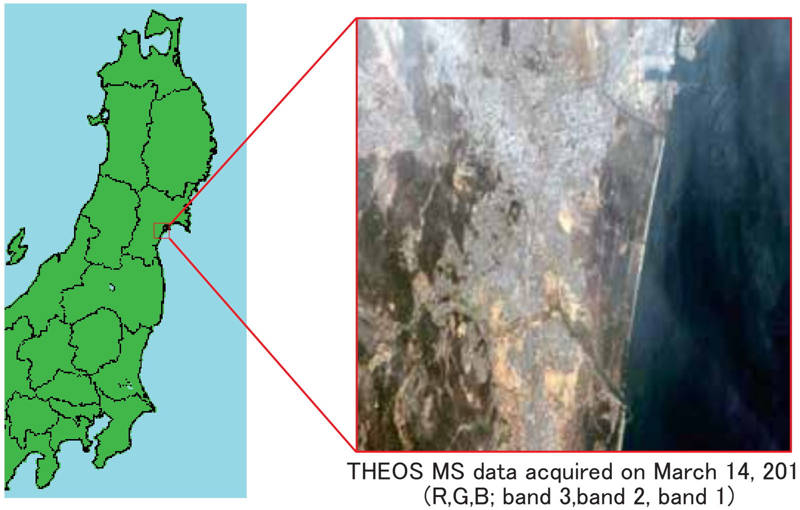
When the resolution of the data is improved, detailed land cover information can be obtained under the conditions of the wide range and high resolution

Both mixels and pure pixels should be considered in order to accurately classify land cover conditions.

Develop a method for unmixing mixels that uses the DNs and textures appeared in remote sensing data

Study area

- The coastal area in Miyagi Prefecture, Japan



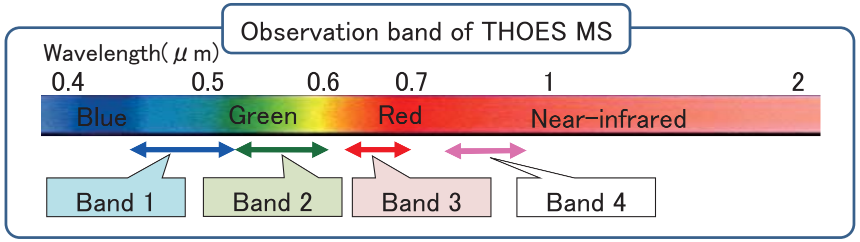
THEOS MS data acquired on March 14, 2011
(R,G,B; band 3,band 2, band 1)

Map: http://www.sekaichizu.jp/atlas/japan/prefecture/map_p/p_area_tohoku.html

Data used

- THEOS(Thailand Earth Observation System)
- The ground sample of the THEOS is 15 m for bands 1 through 4.
- Observation width is 90km

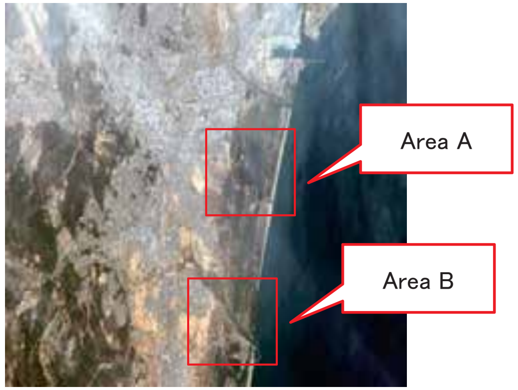
THEOS †



† GISTDA WEB site: http://www.gistda.or.th

THEOS MS data

- Acquired on March 14, 2011
- Select an area overflowed: Areas A and B
- Size of the study area is 230 × 230 pixels



THEOS MS data (R,G,B; band 3, band 2, band 1)

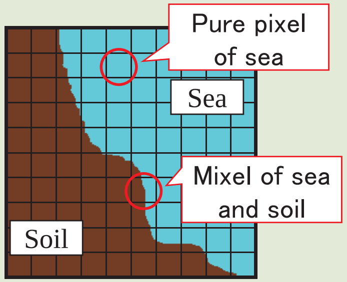
Outline of unmixing Mixels

Unmixing mixls

Concept of pixels in remote sensing data

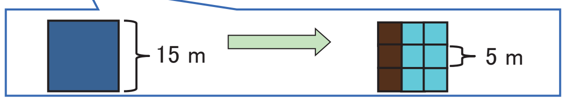
Pure Pixel
Information provided by a pixel should be represented as one-pixel one-class

Mixed Pixel (Mixel)
Information provided by a pixel should be represented as one-pixel mix-class

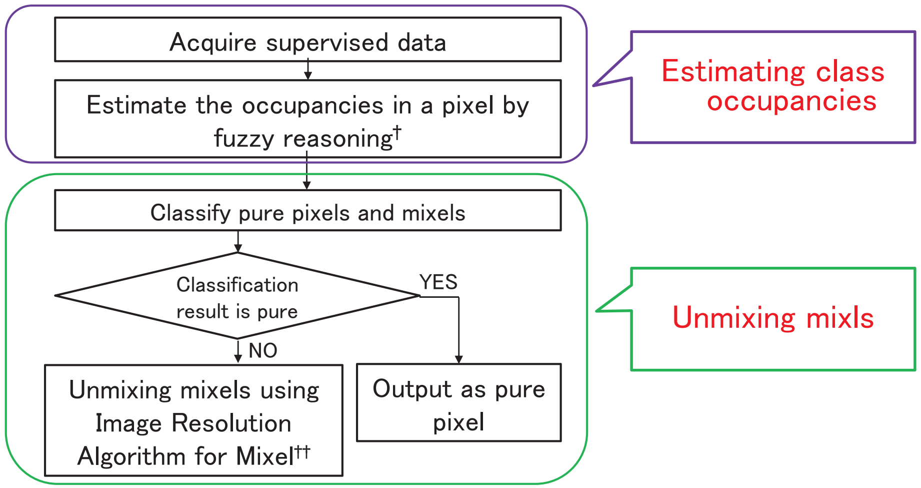


Concept of pure pixel and mixel

Unmixing mixels makes it possible to obtain detailed information buried in the resolution of remote sensing data



Flowchart of the proposed method



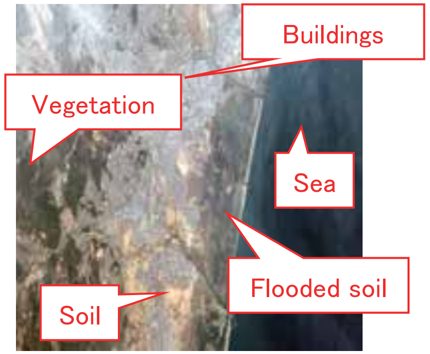
† M. Nishida, K. Otsuka, R. Tabata, “Estimation of Class Mixture Proportion of Mixel due to Fuzzy Reasoning,” Trans. IEE Japan, Vol.116-C, pp.359-366 (1996).

†† Y.Kageyama, M.Nishida, Image Resolution Algorithm for Mixed Pixel in Remote Sensing Data, Trans. IEE Japan, Vol.121-C, No.5, pp.961-966 (2001)

Estimation of class occupancies

Acquisition of supervised data

- five classes— Buildings, Sea, Flooded soil, Vegetation and Soil — were set.
- forty pixels were extracted per class as the supervised data.
- An average and variance of the DNs and the textures were computed, respectively.



An example of extracting supervised data

Acquisition of supervised data

Average and variance of the DNs of the supervised data

class \ band	Band 1		Band 2		Band 3		Band 4	
	Ave.	Var.	Ave.	Var.	Ave.	Var.	Ave.	Var.
Buildings	50.50	7.35	50.75	8.94	58.28	6.85	52.60	6.79
Sea	18.58	1.09	25.18	1.14	37.08	1.12	14.80	1.36
Flooded soil	25.90	1.54	30.28	1.15	40.48	0.90	22.70	5.61
Vegetation	25.03	6.12	29.15	3.78	38.85	3.08	44.43	32.44
Soil	38.05	7.80	36.98	5.37	43.38	3.08	47.78	17.67

Acquisition of supervised data

Average and variance of the textures of the supervised data

class \ band	Band 1		Band 2		Band 3		Band 4	
	Ave.	Var.	Ave.	Var.	Ave.	Var.	Ave.	Var.
Buildings	20.00	10.95	18.26	9.67	19.58	9.87	19.60	5.52
Sea	2.98	1.08	4.06	1.07	6.38	1.11	3.06	0.66
Flooded soil	7.11	0.90	6.59	0.63	8.51	0.29	6.88	0.66
Vegetation	5.38	0.23	5.11	0.09	5.93	0.21	19.49	3.21
Soil	15.89	1.37	12.04	0.72	11.44	0.90	19.52	2.07

Estimation of the occupancies in a pixel by fuzzy reasoning †

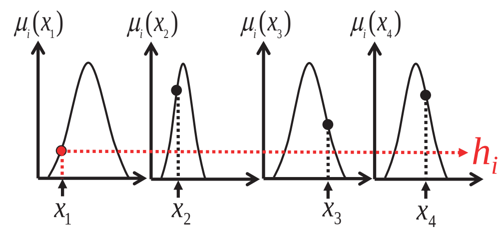
Make a normal distribution type membership function with the average and variance of supervised data

↓

Compute the agreement ratio h_i between input and each rule by min operation

↓

A weighted average of $\vec{Z}_i$ and h_i is computed and expressed as $\vec{Z}_0$



Membership function in each band

Occupancy: $\vec{Z}_0 = \dfrac{\sum_{i=1}^{n} h_i \vec{Z}_i}{\sum_{i=1}^{n} h_i}$

$\vec{Z}_i = (a_{i1}, \cdots, a_{iN})$

: Degree of membership set in each rule

$\vec{Z}_0 = (a_1, \cdots, a_N)$

: Outputs of estimated occupancies

† M. Nishida, K. Otsuka, R. Tabata, "Estimation of Class Mixture Proportion of Mixel due to Fuzzy Reasoning," Trans. IEE Japan, Vol.116-C, pp.359-366 (1996).

Unmixing Mixels

Unmixing mixels by the proposed method

Estimate class occupancies in each pixels using the DNs and the textures

Flooded soil class is included — YES / NO

Ratio obtained using DNs > T1 — YES / NO

Ratio obtained using textures > T2 — YES / NO

(T1 = 0.40, T2=0.40)

Classify it as a pure pixel

For mixels

Re-estimate class occupancies for top 2 classes of the above processing

Magnify mixels on the basis of the class occupancies and their location information†

† Y.Kageyama, M.Nishida, Image Resolution Algorithm for Mixed Pixel in Remote Sensing Data, Trans. IEE Japan, Vol.121-C, No.5, pp.961-966 (2001)

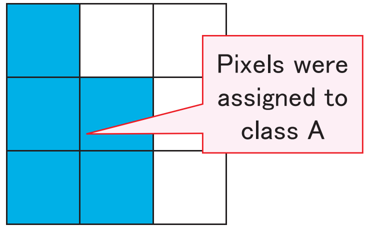
Outline of unmixing mixels proposed in the previous study†

(1) Calculate the priority of the pixel to be attributable to Class A

(2) Based on the priority and occupancy of the original pixel, magnification pixels are outputted as the pure pixels of class A .

5	8	9
2	4	7
1	3	6

Priority in Class A



Output to Class A

An example of making magnification pixels
(Occupancy of Class A is 0.55)

† Y.Kageyama, M.Nishida, Image Resolution Algorithm for Mixed Pixel in Remote Sensing Data, Trans. IEE Japan, Vol.121-C, No.5, pp.961-966 (2001)

Magnification results and Discussion

Study area A

230 pixels

230 pixels

Original image

690 pixels

690 pixels

Magnification result

•The boundaries of the classes and the land cover conditions are clear.
•It is globally in agreement with an actual situation.

Magnification result by the proposed method

Magnification results and Discussion

Study area B

230 pixels

230 pixels

Original image

690 pixels

690 pixels

Magnification result

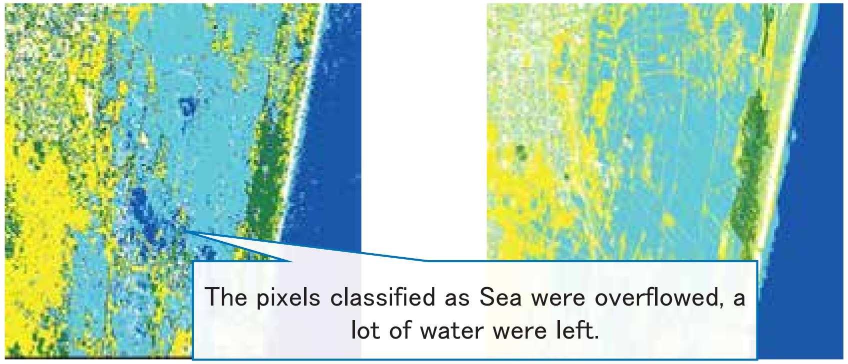
•The boundaries of the classes and the land cover conditions are clear.
•It is globally in agreement with an actual situation.

Magnification result by the proposed method

Classification results and Discussion

Comparison of the classification result and the manually classified map

Study area A



Classification result

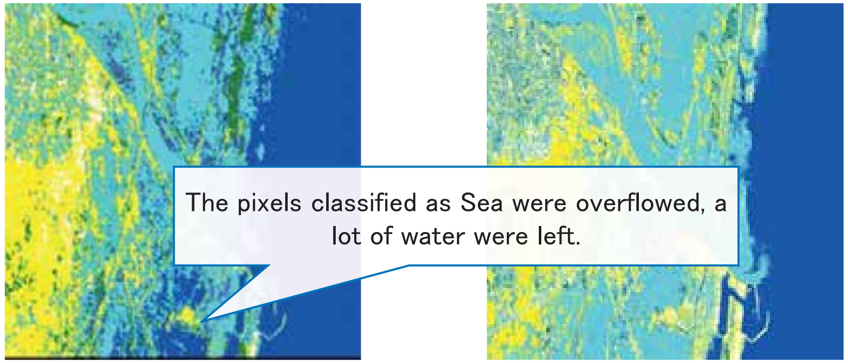
Manually classified map created using the aerial photograph † and the map ††

☐ Buildings ■ Sea ■ Flooded soil ■ Vegetation ■ Soil

† Geospatial Information Authority of Japan :http://saigai.gsi.go.jp/h23taiheiyo-zort/
†† Zenrin Digital Atlas Zi14

Comparison of the land cover classification result and the manually classified map

Study area B



Classification result

Manually classified map created using the aerial photograph † and the map ††

☐ Buildings ■ Sea ■ Flooded soil ■ Vegetation ■ Soil

† Geospatial Information Authority of Japan :http://saigai.gsi.go.jp/h23taiheiyo-zort/
†† Zenrin Digital Atlas Zi14

Calculation of the concordance rate of the proposed method

Concordance rate of the result by the proposed method to the manually classified map (class of the Sea in the Flooded soil is permitted)

class	Study area A		Study area B	
	Rate of land cover [%]	concordance rate [%]	Rate of land cover [%]	concordance rate [%]
Buildings	9.12	83.17	5.92	58.19
Sea	17.46	99.83	29.10	94.35
Flooded soil	42.34	94.04	41.28	92.30
Vegetation	2.52	98.40	2.57	96.29
Soil	28.56	81.16	21.14	79.53
Total		90.44		88.02

The proposed method is in good agreement with the manually classified map

Calculation of the concordance rate of the proposed method

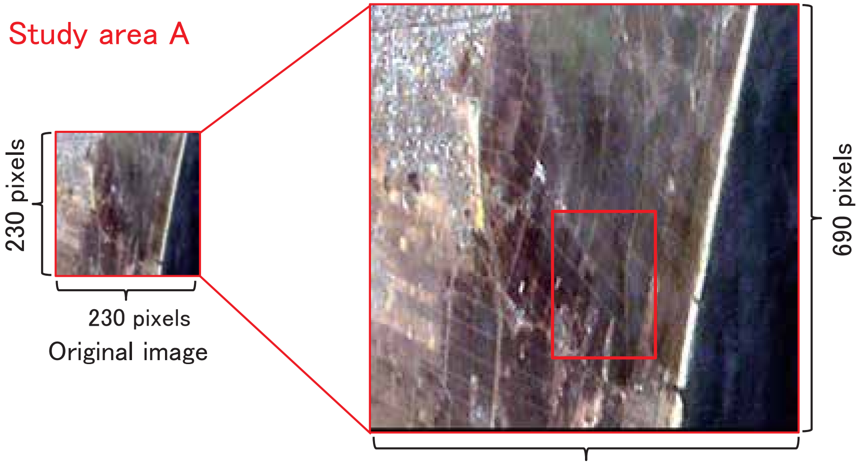
Concordance rate of the result by the proposed method to the manually classified map (class of the Sea in the Flooded soil is permitted)

class	Study area A		Study area B	
	Rate of land cover [%]	concordance rate [%]	Rate of land cover [%]	concordance rate [%]
Buildings	9.12	83.17	5.92	58.19
Sea	17.46	99.83	29.10	94.35
Flooded soil	42.34	94.04	41.28	92.30
Vegetation	2.52	98.40	2.57	96.29
Soil	28.56	81.16	21.14	79.53
Total		90.44		88.02

Study area B：rates of Buildings and Soil are low

⇒ Difficulty in extracting detailed information since they are crowded with artificial structures having the various features

Comparison with the results by the nearest neighbor interpolation

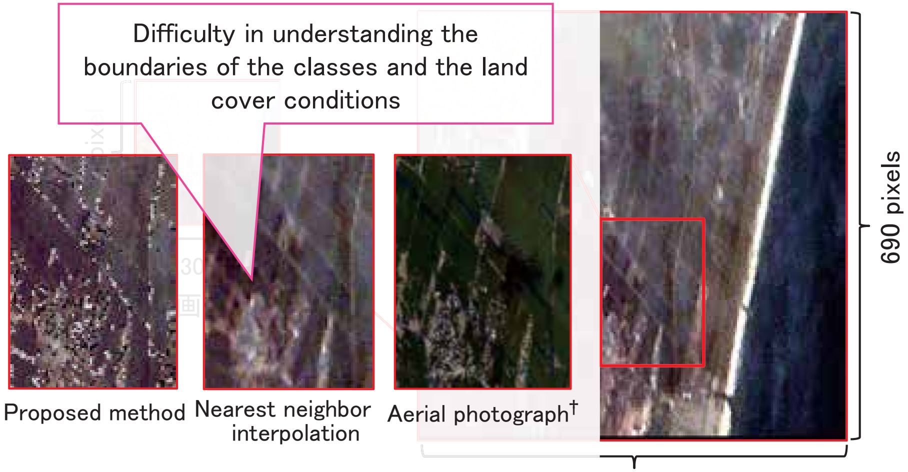


Original image

Magnification result

Magnification result by the nearest neighbor interpolation

Comparison with the results by the nearest neighbor interpolation



Proposed method Nearest neighbor interpolation Aerial photograph†

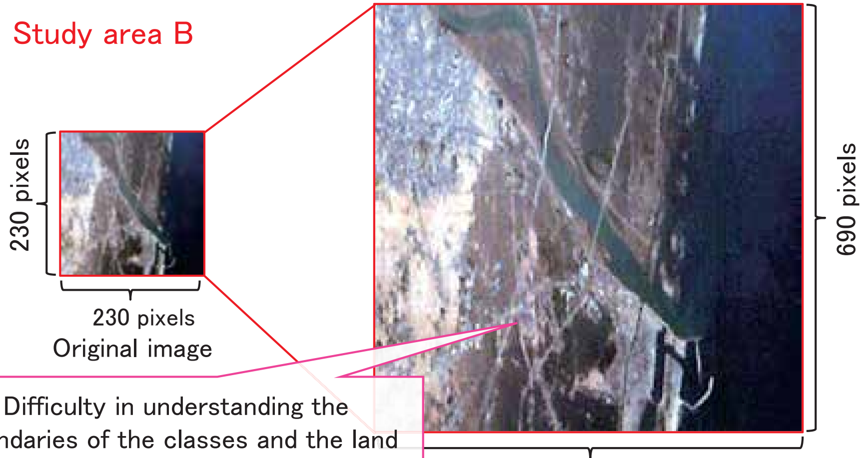
690pixel

Magnification result

Magnification result by the nearest neighbor interpolation

† Geospatial Information Authority of Japan :http://saigai.gsi.go.jp/h23taiheiyo-zort/

Comparison with the results by the nearest neighbor interpolation



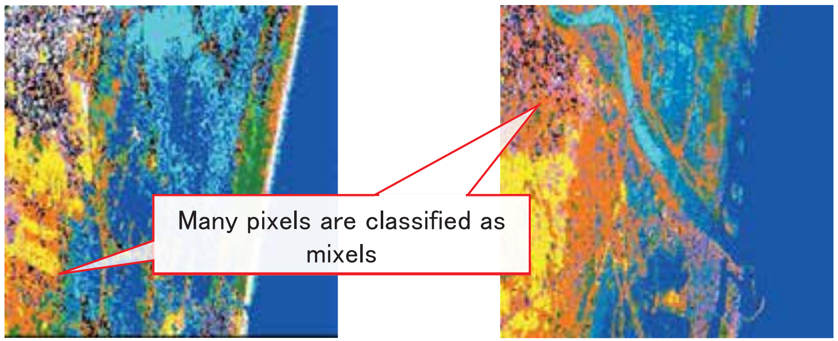
Original image

Magnification result

Magnification result by the nearest neighbor interpolation

Comparison with the results by the nearest neighbor interpolation

Evaluation of the classification result



Study area A Study area B

Classification result by the nearest neighbor interpolation

pure pixels: Buildings(A) Sea(B) Flooded Soil(C) Vegetation(D) Soil(E)
Mixels: A・B A・C A・D A・E B・C B・D B・E C・D C・E D・E Others

Comparison with the results by the nearest neighbor interpolation

Calculation of the concordance rate of the nearest neighbor interpolation

Concordance rate (class of the Sea in the Flooded soil is permitted)

class	Study area A		Study area B	
	Proposed method	Nearest neighbor interpolation	Proposed method	Nearest neighbor interpolation
Buildings	83.17	28.94	58.19	1.88
Sea	99.83	99.79	94.35	94.85
Flooded soil	94.04	70.68	92.30	27.70
Vegetation	98.40	90.96	96.29	43.09
Soil	81.16	23.27	79.53	34.56
Total	90.44	58.67	88.02	47.56

31.77% 40.46%

The proposed method is possible to accurately classify the land cover information

Study on usefulness of the combination of textures and DNs

Calculation of the concordance rate of the processing that uses DNs

Concordance rate (class of the Sea in the Flooded soil is permitted)

Class	Study area A [%]		Study area B [%]	
	Proposed method	Use of DNs	Proposed method	Use of DNs
Buildings	83.17	83.17	58.19	56.41
Sea	99.83	99.99	94.35	95.38
Flooded soil	94.04	89.43	92.30	75.83
Vegetation	98.40	99.99	96.29	87.10
Soil	81.16	83.17	79.53	92.86
Total	90.44	88.29	88.02	84.26

Use of textures and DNs is good for classifying the class of Flooded soil.

Study on usefulness of the combination of textures and DNs

Calculation of the concordance rate of the processing that uses DNs

Concordance rate (class of the Sea in the Flooded soil is permitted)

Class	Study area A [%]		Study area B [%]	
	Proposed method	Use of DNs	Proposed method	Use of DNs
Buildings	83.17	83.17	58.19	56.41
Sea	99.83	99.99	94.35	95.38
Flooded soil	94.04	89.43	92.30	75.83
Vegetation	98.40	99.99	96.29	87.10
Soil	81.16	83.17	79.53	92.86
Total	90.44	88.29	88.02	84.26

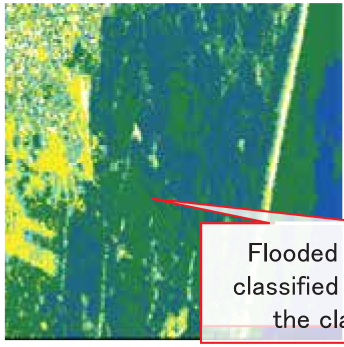
High concordance rate is obtained when using DNs

Need to develop an algorithm to select the process in accordance with the flood situation of the study area

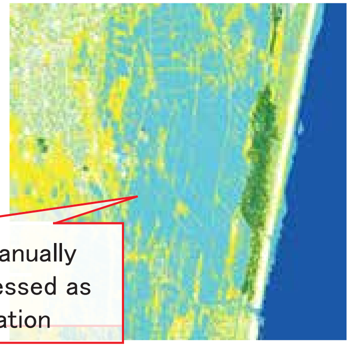
Study on usefulness of the combination of bands 1 to 4

Classification result by using bands 1 to 3 set in the visible range

Study area A



Classification result by the use of bands 1 to 3



Manually classified map created using the aerial photograph † and the map ††

Flooded soil in the Manually classified map is expressed as the class of Vegetation

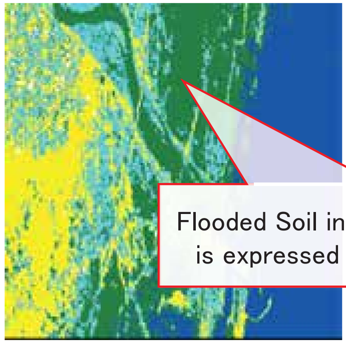
☐ Buildings ■ Sea ■ Flooded soil ■ Vegetation ■ Soil

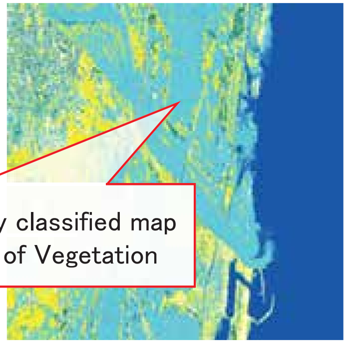
† Geospatial Information Authority of Japan :http://saigai.gsi.go.jp/h23taiheiyo-zort/
†† Zenrin Digital Atlas Zi14

Study on usefulness of the combination of bands 1 to 4

Classification result by using bands 1 to 3 set in the visible range

Study area B





Flooded Soil in the Manually classified map is expressed as the class of Vegetation

Classification result by the use of bands 1 to 3

Manually classified map created using the aerial photograph † and the map ††

☐ Buildings ■ Sea ■ Flooded soil ■ Vegetation ■ Soil

† Geospatial Information Authority of Japan :http://saigai.gsi.go.jp/h23taiheiyo-zort/
†† Zenrin Digital Atlas Zi14

Study on usefulness of the combination of bands 1 to 4

Classification result by using bands 1 to 3 set in the visible range

Average of DNs of Supervised data

	Band 1	Band 2	Band 3	Band 4
Flood Soil	25.90	30.28	40.48	22.70
Vegetation	25.03	29.15	38.85	44.43

No differences in Bands 1 to 3

⇨ Difficult to accurately classify classes by using bands 1 to 3

Difference in reflectance is appeared in the near–infrared region

⇨ DNs in band 4 is useful for the classification

Use of band data in the both visible and near–infrared region is good for accurate classification

Study on usefulness of the combination of bands 1 to 4

Classification result by using bands 1 to 3 set in the visible range

Concordance rate (class of the Sea in the Flooded soil is permitted)

Class	Study area A [%]		Study area B [%]	
	Use of bands 1 to 4	Use of bands 1 to 3	Use of bands 1 to 4	Use of bands 1 to 3
Buildings	83.17	41.28	58.19	12.56
Sea	99.83	61.12	94.35	90.03
Flooded soil	94.04	57.87	92.30	65.02
Vegetation	98.40	100.00	96.29	92.23
Soil	81.16	37.78	79.53	74.64
Total	90.44	52.11	88.02	71.85

High coincidence rate was obtained

Use of band data in the visible and near–infrared region would be appropriate for accurate classification

Conclusions

Development a method for unmixing mixels that uses the DNs and textures appeared in remote sensing data to estimate amount of disaster wastes

- A method for unmixing mixels that uses DNs and textures would be appropriate for estimating land cover information.
- For areas set in the study, concordance rate obtained by the proposed method is about 90 %, and the proposed method is able to improve the resolution of the THEOS data.
- Unmixing mixels using the band data in the visible and near–infrared region is good for accurate classification.
- A method for unmixing mixels proposed in the study enables the improvement of the resolution of remote sensing data when a large–scale disaster occurs.

Estimation Amount of Disaster Debris by Analyzing the Aerial Images

Masahito Yamamoto

Professor, Graduate School of Information Science and Technology, Hokkaido University

Abstract:

In a massive earthquake, it becomes difficult to know the situation of damage immediately because the accesses to the affected areas are lost at the same time. Especially Tsunami leaves much debris and breaks all the accessible roads and houses. In order to recover the cities from the disaster, it is required to arrange the infrastructure such as ground transportations and decide the location of a large number of temporary storages as soon as possible.

The aim of this presentation is to introduce our efforts to detect the damaged building and to estimate the amount of disaster debris (waste) by using aerial photographs just after the disaster and to discuss about the future perspective and the limitation of the proposed methods.

In this study, we focus on the detection of collapsed houses caused by the disaster. If we can know the situation for the area of collapsed houses immediately, the amount of disaster wastes or debris can be estimated. In order to detect whether a certain house is collapsed or not, we used aerial photographs and map data.

At first, our proposed method focuses on a house on the map image. Next, the system trims aerial photograph in the same position from the coordination values of the house in the image so as to include just one house in a trimmed image. The images are transformed from the color images to gray scale images and the edges in the images are extracted by the sobel filter. Then the line can be extracted by applying the medhod by Duda and Hart. Our proposed method is shown in the followings.

1) Image data are prepared

2) Regions of houses are trimmed from the images

3) Characteristics are extracted from the images

4) Classification that each house is collapsed or not is performed

5) Amounts of disaster debris are estimated

Fig 1 shows the result of estimating collapsed houses. We can find that many houses are collapsed and our proposed method almost can detect collapsed houses. Table 1 show the actual percentage of Fig 1.

Table 1 Detection Results

		Actual Damage		Total
		Collapsed	Not-Collapsed	
Proposed Method	Collapsed	0.288	0.191	0.479
	Not-Collapsed	0.142	0.379	0.521
Total		0.892	0.570	1.000

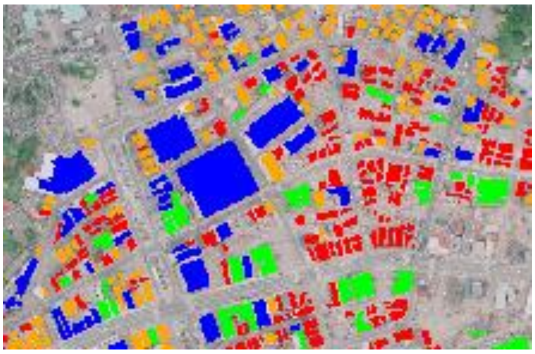


Fig. 1 Classified Areas

From the table, we can see that the percentage of correct answer is 0.667, Precision is 0.602, and Recall is 0.670. In this evaluation method, two types of reasons caused incorrect classifications. One pattern is the proposed method decides house “collapsed”, but actual damage is not collapsed. This error occurs in that the threshold of detecting straight lines by Hough transform is not appropriate. Hence in order to overcome the problem, it is necessary to combine a different technique from line-detection. On the other hand, there are some cases that the proposed method decides the house is “not-collapsed”, but the actual damage is collapsed. The reason why these misclassifications are occurred is that some houses are collapsed with the flood above the floor level and so roofs are not damages.

It is shown that our proposed method can estimate the disaster debris with high accuracy comparing with existing methods.

References

[1] Hirayama,N., Kawata,Y, Okumura,Y. Quantitative Estimation of Disaster Debris for Operational Management after the Great East Japan Earthquake. Japan Society of Material Cycles and Waste Management Vol.23,No.1:3-9. 2012

[2] The Great East Japan Earthquake Reconstruction Support Research Archive, http://fukkou.csis.u-tokyo.ac.jp

[3] Cabinet Office, Geverment of Japan, http://www.bousai.go.jp/taisaku/pdf/shishin002.pdf

Estimation Amount of Disaster Debris by Analyzing the Aerial Images

Masahito Yamamoto
Professor,
Graduate School of Information Science and Technology, Hokkaido University

Background

- For the recovery from the disaster, it is very important to know the damage status of the area

Estimation of disaster debris
↓
Planning for recovering
↓

Transportation	Wide-area treatment
Temporal storages	Temporal facilities



Estimation of disaster Debris

Damage area × Base unit = Amount of Debris ?


For General house
0.62[ton/m^2]

[Takatsuki et al.,1995] [Hirayama et al., 2010]

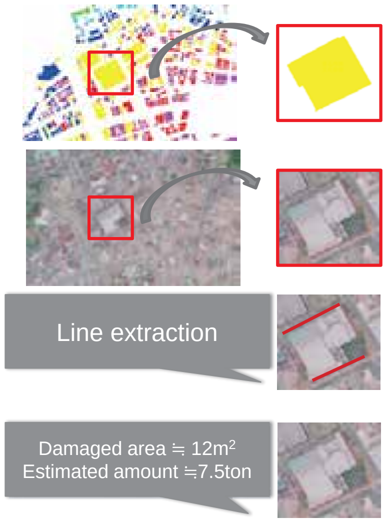
Purpose

- Automatic detection whether a certain building is destroyed or not

Destroyed? or not?

We can estimate the amount of disaster debris considering for destroyed area

Procedure



Trimming of the map image

↓

Trimming of the areal image

↓

Extraction of characteristics
Detection of destroyed or not

↓

Estimation of the amount of disaster debris

Experimental Results

Precision of our proposed method are examined

Experimental conditions are follows

- Data set
  - Areal images after the disaster
  - Map data
- Images (three typical types of cities or towns)
  - Minami-Sanriku town
  - Rikuzen-Takata city
  - Kamaishi city

Evaluation criteria

Archive of recovery support survey

- Supporting group surveyed the damaged area after disaster
- Disaster damage status of each building is available

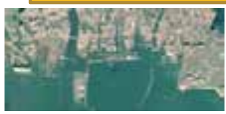
Damaged area of Minami-Sanriku town

Red : Washed away
Pink : Totally destroyed
Blue : Seriously damaged
Green : Partially damaged

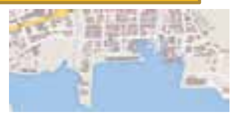
Image Data

- Three types of cities or towns

Minami-Sanriku town



After disaster(11/3/12-13)



Map data

Rikuzen-Takata city

After disaster (11/4/1)

Map data

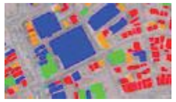
Kamaishi city

After disaster(11/5-12/3)

Map data

実験結果における各領域の凡例

		実際の倒壊情報	
		倒壊	非倒壊
提案手法	倒壊	Ar	Ao
	非倒壊	Ag	Ab



- 正答率：提案手法が被害の判別に成功した領域の割合

$$S=\boxed{A_r}+\boxed{A_b}$$

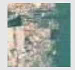
- 適合率

$$P=\frac{\boxed{A_r}}{\boxed{A_r}+\boxed{A_o}}$$

- 再現率

$$R=\frac{\boxed{A_r}}{\boxed{A_r}+\boxed{A_g}}$$

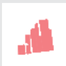
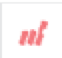
Results (1/3) – Minami-Sanriku Town

Example of destroyed building	
Map data	Areal image
	
	

		Actual Damages		
Estimation		Destroyed	Non-Dest.	Toral
	Destroyed	0.822(Re)	0.012(Or)	0.834
	Non-Dest.	0.166(Gr)	0.000(Bl)	0.166
	計	0.988	0.012	1.000

Accuracy : 0.823
Precision : 0.986
Recall : 0.832

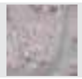
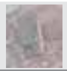
Results (2/3) – Rikuzen-Takata city

Example of destroyed building	
Map data	Areal image
	
	

		Actual Damages		
Estimation		Destroyed	Non-Dest.	Toral
	Destroyed	0.826(Re)	0.083(Or)	0.909
	Non-Dest.	0.066(Gr)	0.025(Bl)	0.091
	計	0.892	0.108	1.000

Accuracy : 0.850
Precision : 0.908
Recall : 0.926

Results (3/3) – Kamaishi city

Example of destroyed building	
Map data	Areal image
	
	

		Actual Damages		
Estimation		Destroyed	Non-Dest.	Toral
	Destroyed	0.288(Re)	0.191(Or)	0.479
	Non-Dest.	0.142(Gr)	0.379(Bl)	0.521
	計	0.430	0.579	1.000

Accuracy : 0.667
Precision : 0.602
Recall : 0.670

Comparison with actual amount of disaster debris

	Minami-Sanriku	Rikuzen-Takata	Kamaishi
A) Actual Debris[ton]	68.2万	65.9万	15.7万
B) Estimated Debris[ton]	57.6万	67.2万	17.5万
B/A	0.843	1.012	1.113

Concluding Remarks

- Proposed method can estimate the amount of disaster debris more precisely comparing with the previous studies
- More precise estimation methods are required because the proposed method can not always detect the destroyed area in the condition of flood above/under floor level

Analysis of aerial photographs and satellite images for the estimation of mega-disaster waste in devastated areas

Issues of Disaster Waste Transport Planning

Kunihiro Kishi

Associate Professor, Graduate School of Engineering, Hokkaido University

1. Introduction

After the East Japan Great Earthquake Disaster in 2011, municipalities in disaster area are steadily advance reconstruction. As for disaster waste disposal, about 20 million ton of disaster waste and 11 million ton of tsunami deposit occurred in 239 municipalities of 13 prefectures, those disaster waste disposal completed in March 2014 with the exception of a part of Fukushima.

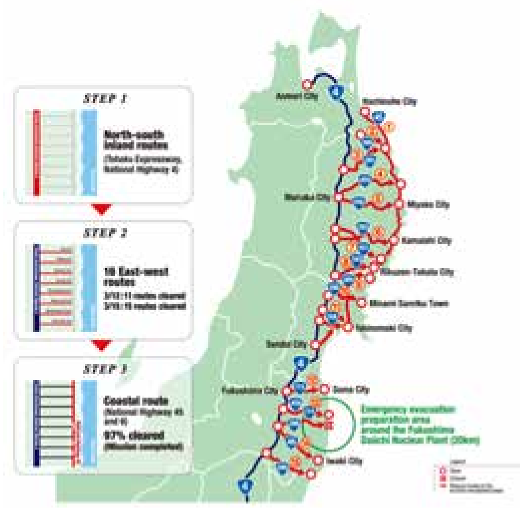
In order to develop reconstruction, it is needless to say that rapid disaster waste disposal is quite important. From the viewpoint of transportation, before establishing disaster waste transport system, rapid recovery of transportation network is important, such as road clearance by removing debris.

This paper discusses issues of disaster waste transport planning, especially focusing on road clearance project. Operation "Teeth of a Comb" and the discussion of Hokkaido about disaster prevention planning are applied as case studies.

2. Operation "Teeth of a Comb"

The road clearance works secure a route just wide enough for a car to get through. From the day following the earthquake, "road clearance" works (Operation "Teeth of a Comb") were started[1].

The operation was named after the shape of the road network under Operation, where the Tohoku Expressway and Route 4 run inland Tohoku from north to south, and a number of debris-covered roads to be cleared extend from the expressway and Route 4 toward the coast. The road clearance works were



Reference: Website of Tohoku Regional Bureau, MLIT

Fig.1 Outline of Operation "Teeth of a Comb"

Fig.2 Road clearance work in Rikuzen-Takata

almost completed by March 18, 2011: 97% of Route 45 was reopened to traffic, etc. From March 18, the project proceeded to the temporary restoration phase.

3. Examination Case of Road Clearance Plan in Hokkaido

Hokkaido Regional Development Bureau, Ministry of Land, Infrastructure, Transport and Tourism established "Investigative committee of rehabilitation for tsunami disaster in winter" in 2013, and I joined this committee. This committee simulated how long it takes to clear debris from the roads in the case of tsunami disaster in Hokkaido, and discussed how construction machines can be secured by wide-range cooperation in Hokkaido [2].

As a case study, Figure 3 is the result of simulation about road clearance when 50 % of construction machines can be used. It takes 4 days and 20 hours to complete road clearance by the support of construction machines from other areas. In the case of

Fig.3 Required time for road clearance(non-snowy season)

Fig.4 Required time for road clearance (snowy season)

winter seasons, it takes more than twice of non-snowy season, because amount of debris includes snow and ice (Fig.4).

4. Issues of Disaster Waste Transport Planning

Many municipalities are making the plan for disposal of disaster waste. Ministry of the Environment provides a guideline for disaster waste provision[3]. This guideline includes disaster waste transport plan. However in face, it seems difficult to secure enough trucks in the case of disaster as Hokkaido Regional Development Bureau discussed. Plans of Road clearance and disaster waste disposal should be discussed with severe conditions and researches on methodology that supports making plans are required.

References

[1] Tohoku Regional Bureau, Ministry of Land, Infrastructure, Transport and Tourism, "Earthquake Memorial Museum", URL: http://infra-archive311.jp/

[2] Hokkaido Regional Development Bureau, Ministry of Land, Infrastructure, Transport and Tourism, "Report of rehabilitation for tsunami disaster in winter"(only in Japanese) (2014)

[3] Ministry of the Environment, "Guideline of disaster waste provision"(2014)

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The 3rd UN World Conference on Disaster Risk Reduction in Sendai
PUBLIC FORUM
Analysis of aerial photographs and satellite images for the estimation of mega-disaster waste in devastated areas

Issues of Disaster Waste Transport Planning

2015/03/15

UN World Conference on Disaster Risk Reduction 2015 Sendai Japan

仙台環境開発株式会社

Tohoku University DRR Actions
Contributing to Global Disaster Resilience

Kunihiro KISHI, Ph.D
Associate Professor
Hokkaido University

Introduction

- After the East Japan Great Earthquake Disaster in 2011, municipalities in disaster area are steadily advance reconstruction.
- As for disaster waste disposal, about 20 million ton of disaster waste and 11 million ton of tsunami deposit occurred in 239 municipalities of 13 prefectures, those disaster waste disposal completed in March 2014 with the exception of a part of Fukushima.
- In order to develop reconstruction, it is needless to say that rapid disaster waste disposal is quite important.
- From the viewpoint of transportation, before establishing disaster waste transport system, rapid recovery of transportation network is important, such as road clearance by removing debris.

Introduction(2)

- Operation “Teeth of a Comb”
- The discussion of Hokkaido about disaster prevention planning are applied as case studies.
- Ministry of the Environment provides a guideline for disaster waste provision.

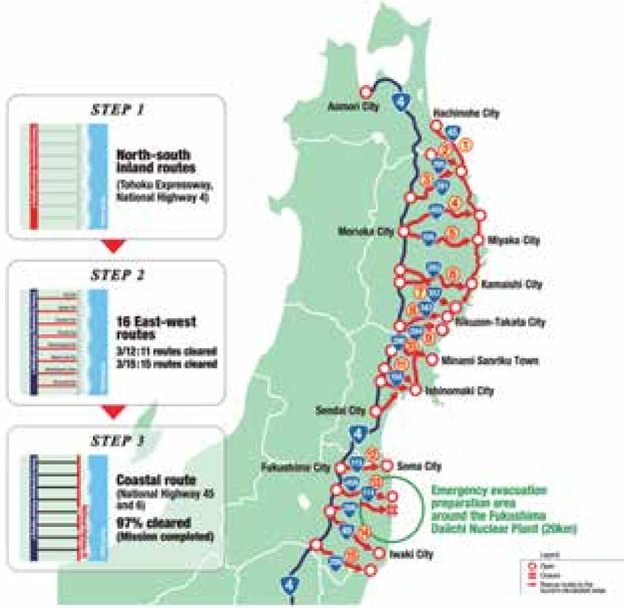
- This paper discusses issues of disaster waste transport planning, especially focusing on road clearance project.

Operation “Teeth of a Comb”

- The road clearance
  - To secure a route just wide enough for a car to get through.
- From the day following the earthquake, “road clearance” works (Operation “Teeth of a Comb”) were started.
- The operation was named after the shape of the road network under Operation,
- where the Tohoku Expressway and Route 4 run inland Tohoku from north to south, and a number of debris-covered roads to be cleared extend from the expressway and Route 4 toward the coast.

Outline of Operation "Teeth of a Comb"

4



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Examination Case of Road Clearance Plan in Hokkaido

5

- Hokkaido Regional Development Bureau, Ministry of Land, Infrastructure, Transport and Tourism established "Investigative committee of rehabilitation for tsunami disaster in winter" in 2013
- I joined this committee.
- This committee simulated how long it takes to clear debris from the roads in the case of tsunami disaster in Hokkaido, and discussed how construction machines can be secured by wide-range cooperation in Hokkaido

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Input data for road clearance simulation

6

稚内地区	バックホウ	トレーラー
フェーズ①	105台	20台
フェーズ②	807台	

留萌地区	バックホウ	トレーラー
フェーズ①	98台	10台
フェーズ②	481台	

札幌地区	バックホウ	トレーラー
フェーズ①	185台	70台
フェーズ②	5,301台	

小樽地区	バックホウ	トレーラー
フェーズ①	44台	20台
フェーズ②	1,383台	

函館地区	バックホウ	トレーラー
フェーズ①	335台	60台
フェーズ②	2,000台	

空知地区	バックホウ	トレーラー
フェーズ①	182台	30台
フェーズ②	1,734台	

室蘭地区	バックホウ	トレーラー
フェーズ①	280台	140台
フェーズ②	2,063台	

旭川地区	バックホウ	トレーラー
フェーズ①	333台	50台
フェーズ②	2,486台	

網走地区	バックホウ	トレーラー
フェーズ①	71台	40台
フェーズ②	1,416台	

釧路地区	バックホウ	トレーラー
フェーズ①	242台	60台
フェーズ②	1,873台	

帯広地区	バックホウ	トレーラー
フェーズ①	285台	100台
フェーズ②	1,873台	

全道	バックホウ	トレーラー
フェーズ①	2,150台	600台
フェーズ②	21,417台	

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Result of road clearance simulation

7

Case study) maritime area along Pacific Ocean, non-snowy season, estimated amount of debris=110,000m^3

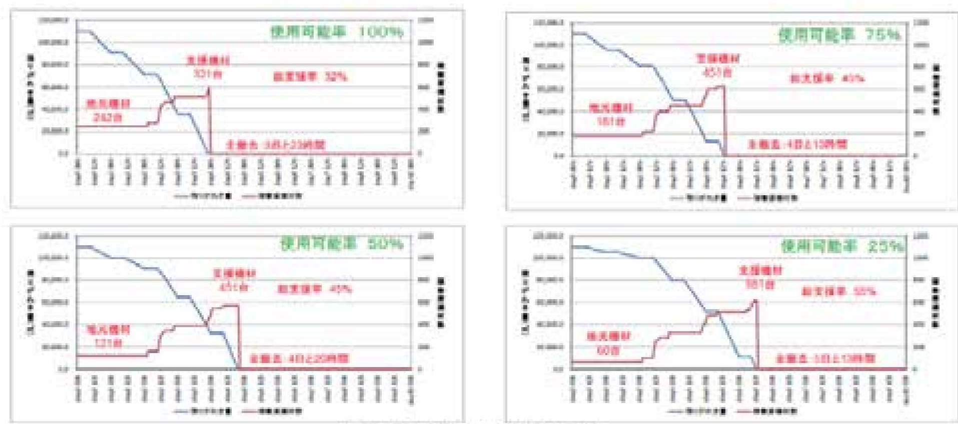

図 がれき撤去量と支援機材台数の推移

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Result of road clearance simulation(2)

8

Case study) maritime area along Pacific Ocean, snowy season, estimated amount of debris=176,000m^3

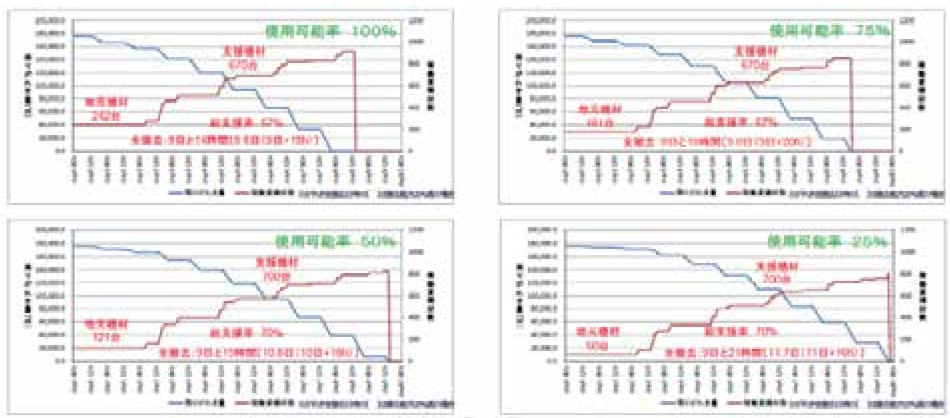

図　がれき撤去量と支援機材台数の推移

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Guideline for disaster waste provision by Ministry of the Environment

9

- Many municipalities are making the plan for disposal of disaster waste.
- Ministry of the Environment released in 2014
- Related to disaster waste transport plan
  - Cooperative framework with General Constructors Association and Industrial Waste Association
  - Make the list of trucks for disaster waste transport
  - Estimate amount of disaster waste and required number of truck
  - Route plan considering traffic congestion

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Issues of Disaster Waste Transport Planning

10

- It seems difficult to secure enough trucks in the case of disaster
  - as Hokkaido Regional Development Bureau discussed.
  - Competitive situation to secure construction machines in disaster area
- Who should coordinate, municipalities or National government?

↓

- Plans of Road clearance and disaster waste disposal should be discussed with severe conditions
- Researches on methodology that supports making plans are required.

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Analysis of aerial photographs and satellite images for the estimation of mega-disaster waste in devastated areas

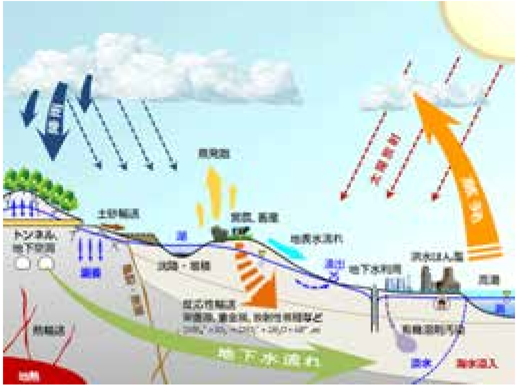
Building of Water Resource Management System with Integrated Water Cycling Simulation

Hiroshi Yamamura

（Assistant Professor of Laboratory of Sustainable Water Metabolic System Engineering, Faculty of Science and Engineering, Chuo University）

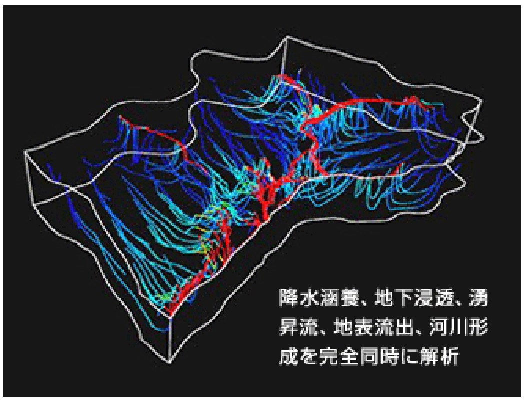
Abstract:
You may think that water flows from the high to low, but in fact sometimes the water climb toward the higher place depending on the conditions. Where and how much water flows is determined by "hydrodynamics". Until now, various researchers predict the water flow by the use of mathematics and physics and have been found various natural laws. For fluid dynamics, most important and fundamental law is "continuous rule", which indicates “the volume of influent have to that of effluent ". Except for the continuous rule, there are some rules to express the natural rules in accordance with natural rules. For examples, momentum and energy of the water is the other essential water flow equation. By assembling these equations, the water flow will be expressed in the virtual space.

In the late 20th century, the techniques of computational fluid dynamics rapidly developed and became possible to create a real fluid on the virtual. Where and how much water flow is now possible to be predicted by simulating the movement of water through the various physical and chemical parameters described before and its accuracy improved year by year with the increase of the performance of computer. Thus, the computer simulation makes us possible to see the current blind world which is impossible to see by our naked eyes.

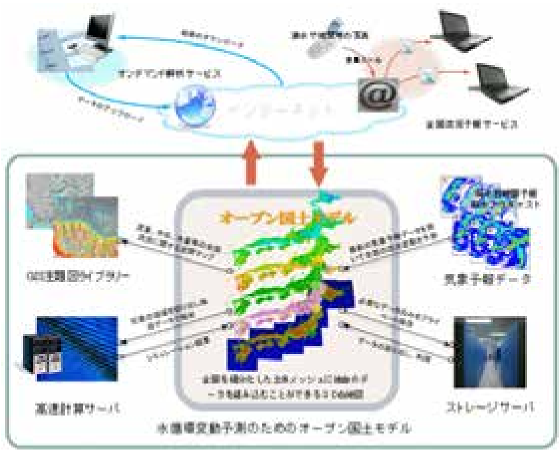


One such example is the ground water flow. Groundwater flow is strongly influenced by the interaction between grain size of particles and the water, the water viscosity

and certainly geology. Therefore, it is very difficult to predict the ground water flow through the computer simulation. Moreover, because the ground water are always supplied from surface water, it is necessary to create an integrated model of ground water and surface water, which makes more difficult to make a simulation model of ground water.



Traditionally, the groundwater flow is monitored by digging some holes from the ground into the basement and directly measured where and how much water flow. In recent years, Geosphere Environmental Technology Corporation succeeded the development of water circulation model which includes both ground and underground water by using a multiphase multicomponent fluid system. This model could visualize the very complex ground water flow. Simulation software are now commercially available as "GETFLOWS", and Geosphere Environmental Technology Corporation is now preparing the visualization of ground water current of all underground space in Japan, as the national project “Open Land, water circulation model".



Well, let us think about what's possible by the use of this model. First question we should ask is that do you know how much water resources in the current Japan? The amount of surface water is now possible to quantify by using the GPS or some tools. However, the abundance of underground is still unknown so far, despite that some studies showed the volume of ground water is much larger than that of surface water. Now, we can predict the total amount of water resource in Japan through the simulation. If we know the accurate amount of water resources, the value of water could be visualized and appropriate doctrine would be carried out to protect water resources in terms of quality and quantity.

In addition, the visualization of underground water would be useful to predict the sediment disaster. The clarification of the ground water flow will inform the place that will be collapse with the heavy rain. The computer simulation makes us see the “future” in unpredictable future world!

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謝辞

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