第３回リモートセンシング技術を用いた災害軽減に関する研究委員会

話題提供資料

震災復興デジタルアーカイブとしての Chi-Chi City on Google Earth の構築
（村尾修）

QuickBird 画像と航空写真による移動体の速度検出（山崎文雄・Liu Wen）

中越沖地震における原子力発電所の被害（中井正一）

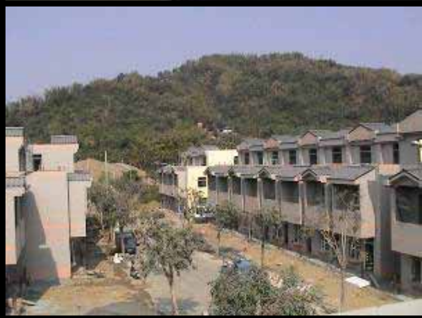
震災復興デジタルアーカイブとしての Chi-Chi City on Google Earthの構築

筑波大学大学院システム情報工学研究科
村尾修

Graduate School of Systems and Information Engineering
University of Tsukuba
www.murao.net

Location of Chi-Chi and the Epicenter

2002/01
（模型）



2002/01

2002/08

集集復興過程
定点観測

復興住宅（新社区）

OMS

1999/10
（避難場所）

2000/04

2002/08
（南投県観光センターの建設）

集集復興過程
定点観測

駐車場

OMS

集集復興過程
定点観測

住宅 (1)

1999/10

2000/04

2002/01

集集復興過程
定点観測

住宅 (2)

1999/10

2000/04

2002/01

集集復興過程
定点観測

集集鉄道駅舎

1999/10

2002/01

2002/08

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集集復興過程
定点観測

地下駐車場

1999/10

2000/04

2002/01

OMS

集集復興過程
定点観測

集集国民小学校

1999/10

2000/04

2002/08

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建物復興状況コード表

	コード	被災･復興区分	内容
被災状況	1	全壊	全壊または倒壊した建物
	2	半壊	半壊した建物
	3	その他	一部損壊または被害なしの建物
	4	空地	宅地として利用されていない土地(檳榔畑等)
復興状況	11	更地（撤去済）	被害を受け，更地となっている土地
	12	建設中	再建・新築のために建設中の建物
	13	再建済	被災後に建替えた建物
	22	修復中	主に半壊を受け修復中の建物
	23	修復済	主に半壊を受け修復した建物
	33	新築	空地を利用して新たに建設された建物
	34	撤去中	被災し，瓦礫を撤去中の土地
	43	被害なし	「その他」判定の建物

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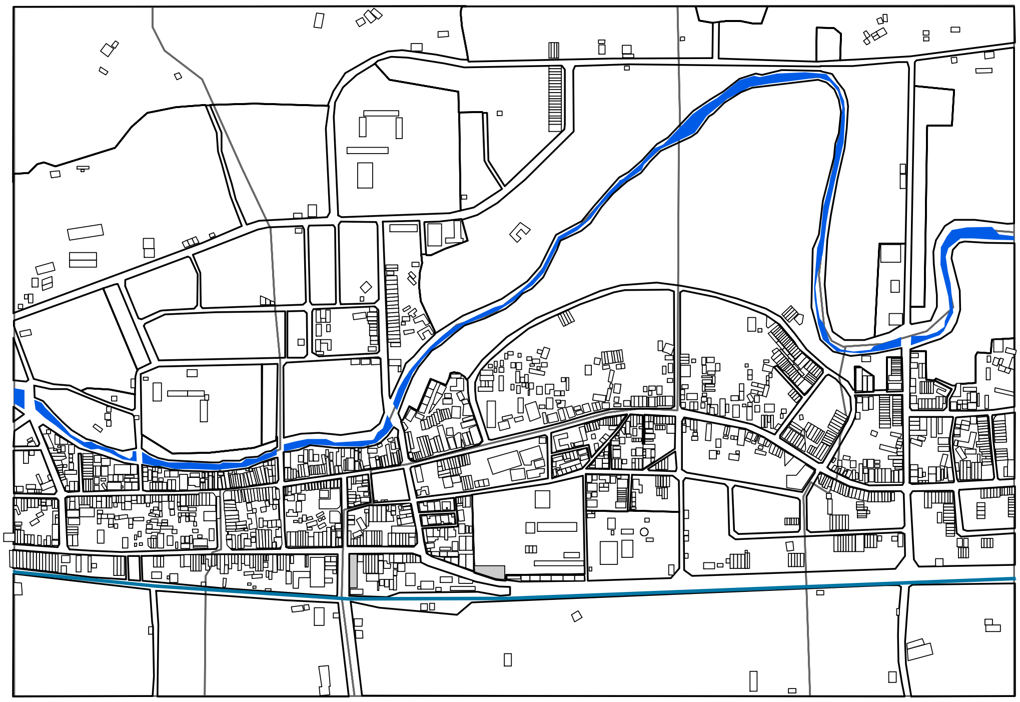
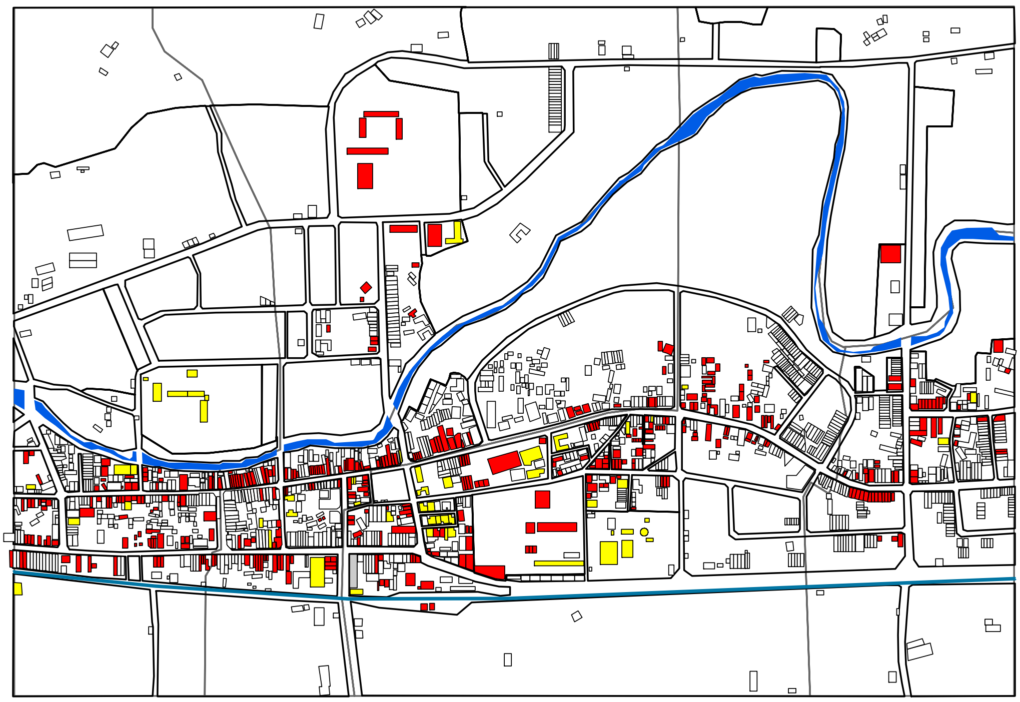
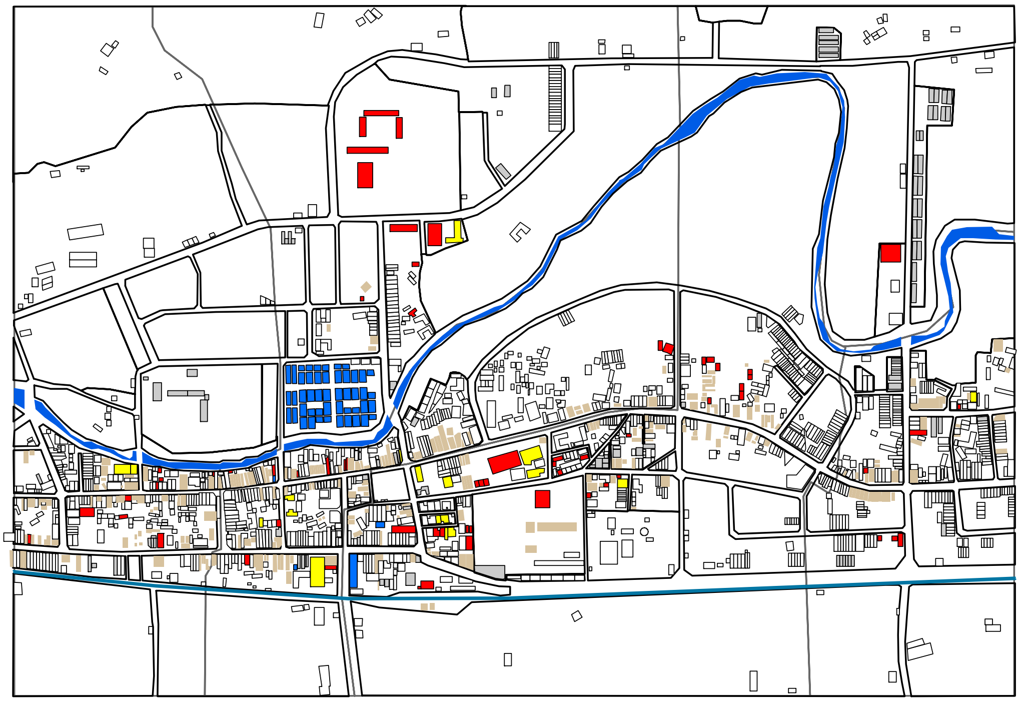
地震直前（1999年9月）



地震による被災状況（1999年9月21日）



半年後（1999年4月）



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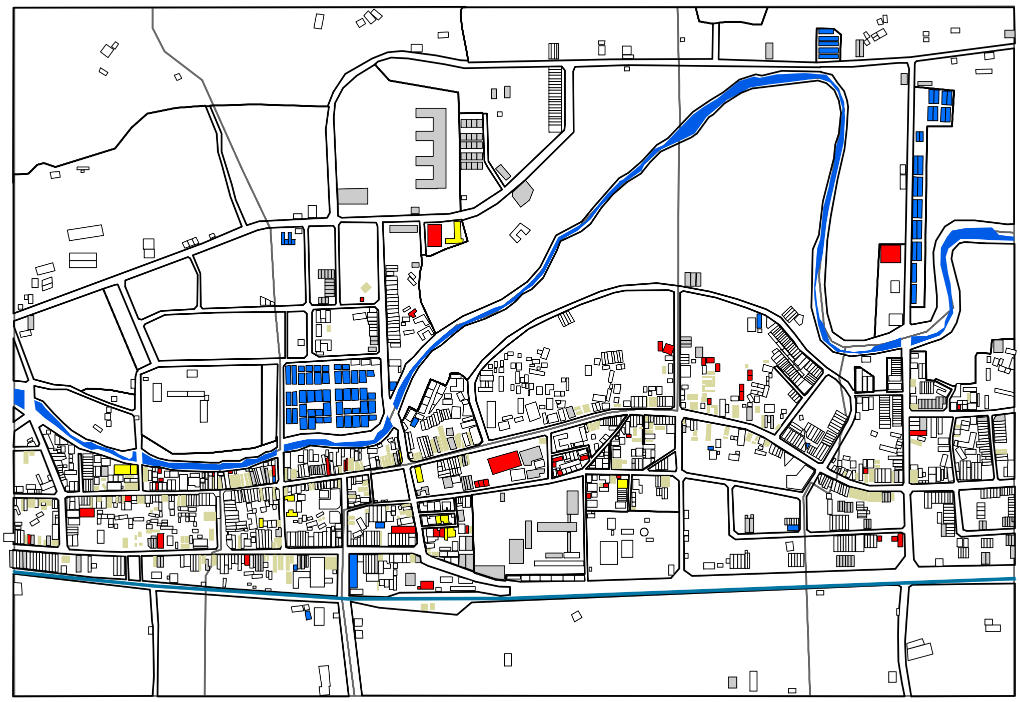
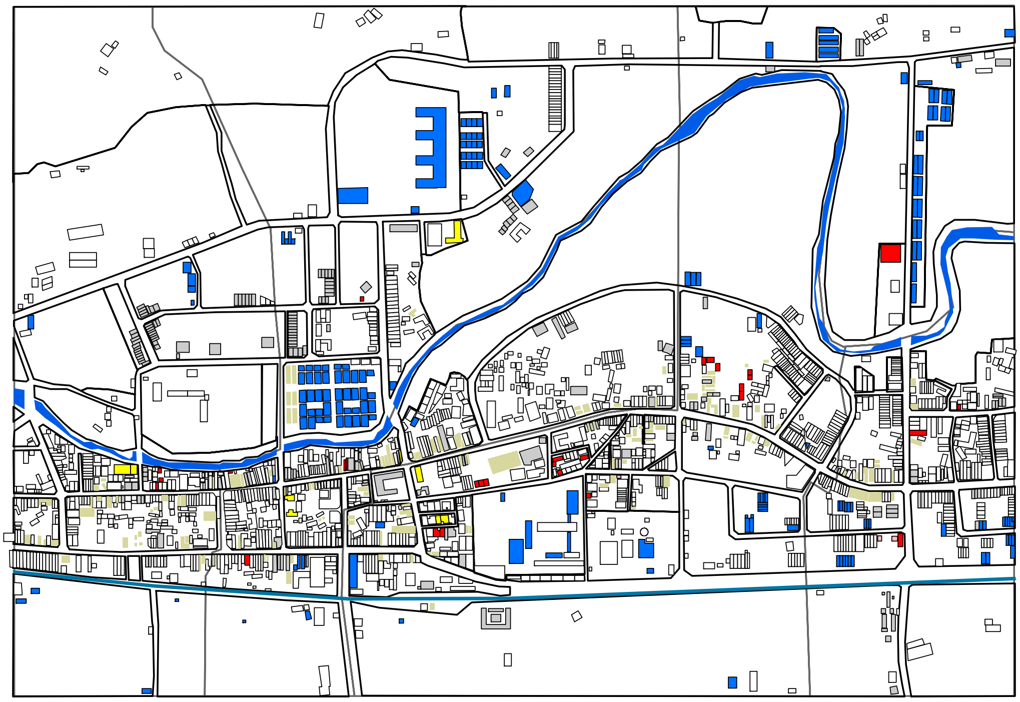
1年後（2000年9月）



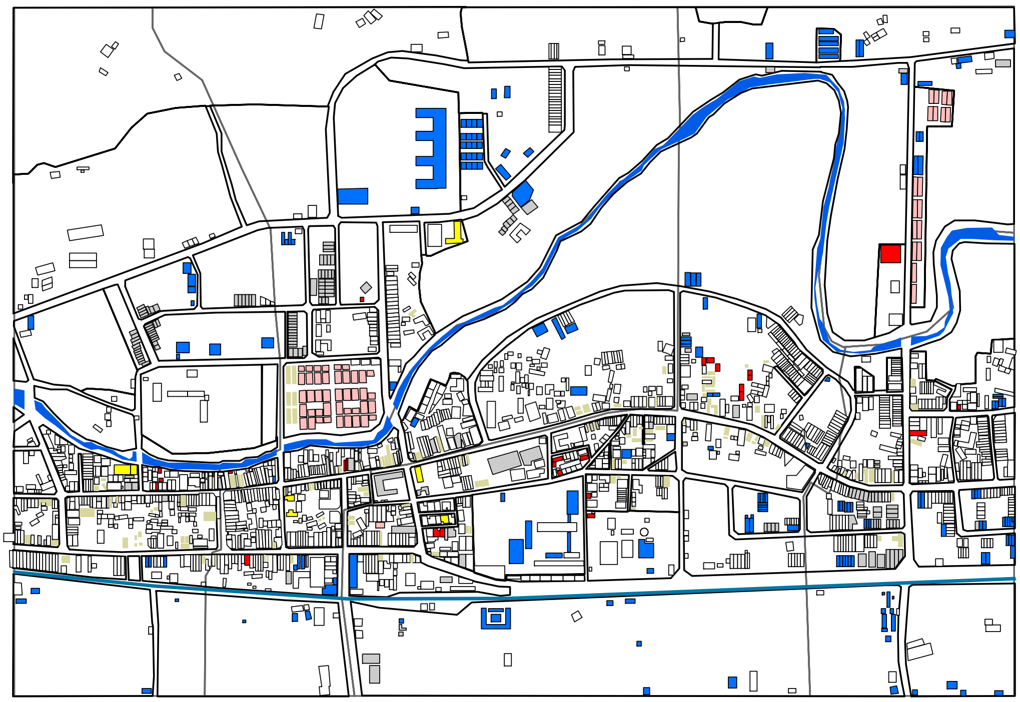
OMS

1年3ヶ月後（2002年1月）



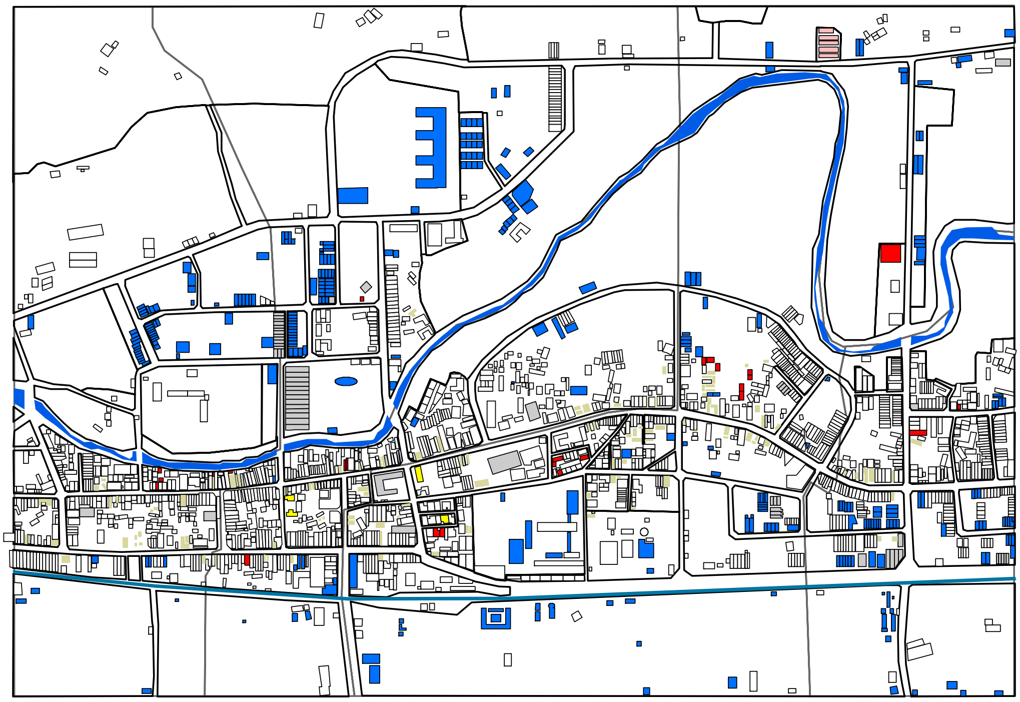
OMS

2年11ヶ月後（2002年8月）



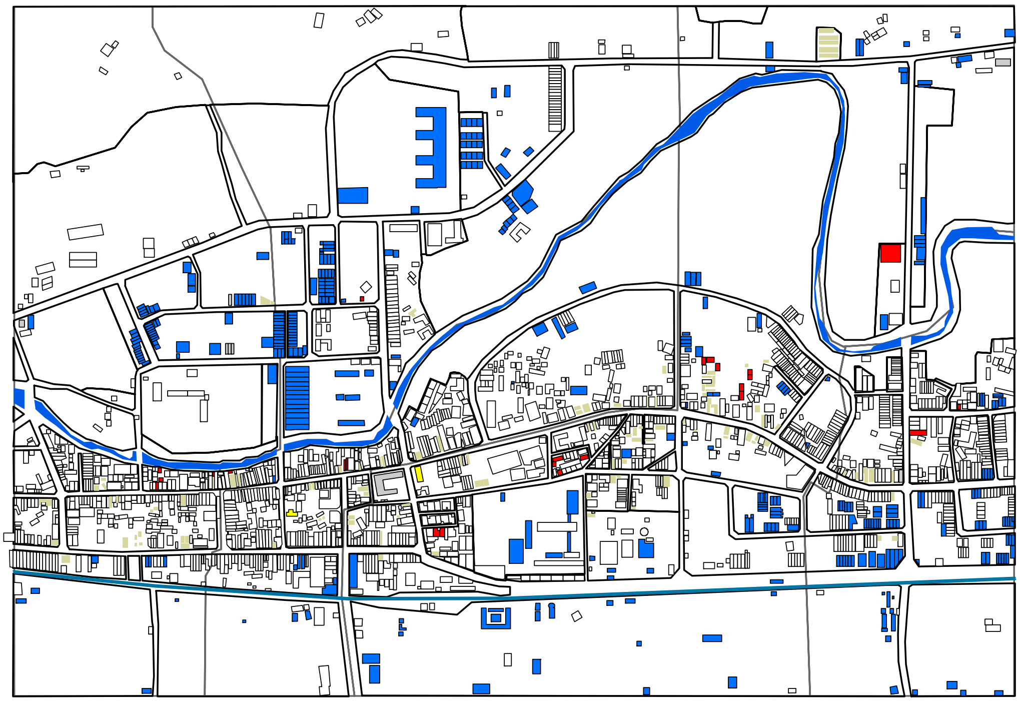
OMS

4年後 (2003年9月)



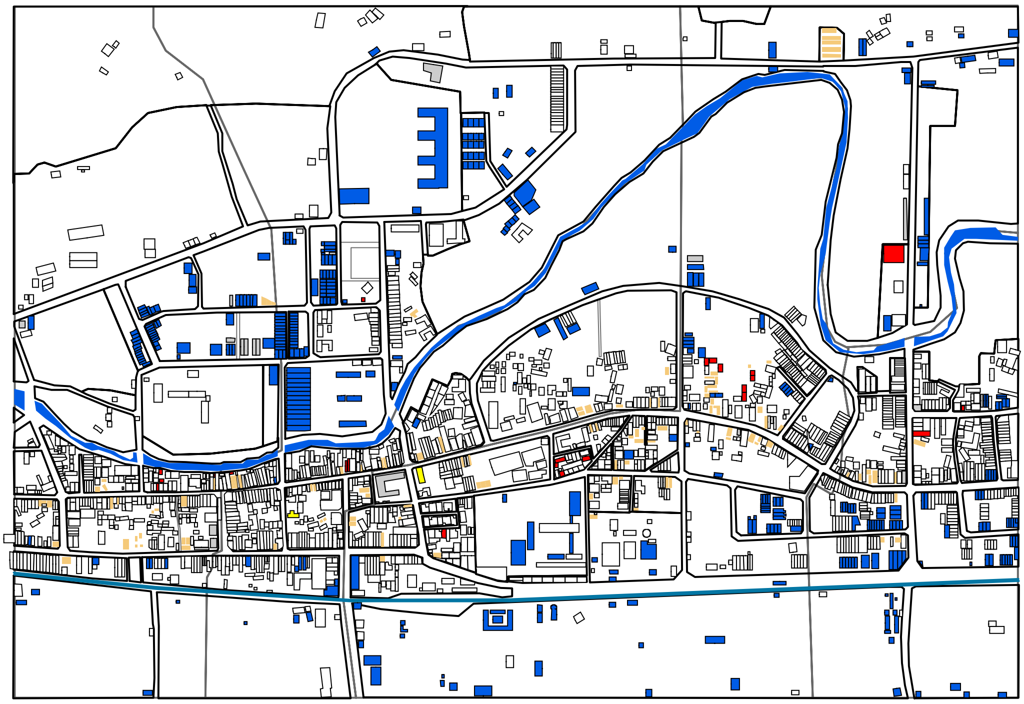
OMS

5年2ヶ月後 (2004年12月)

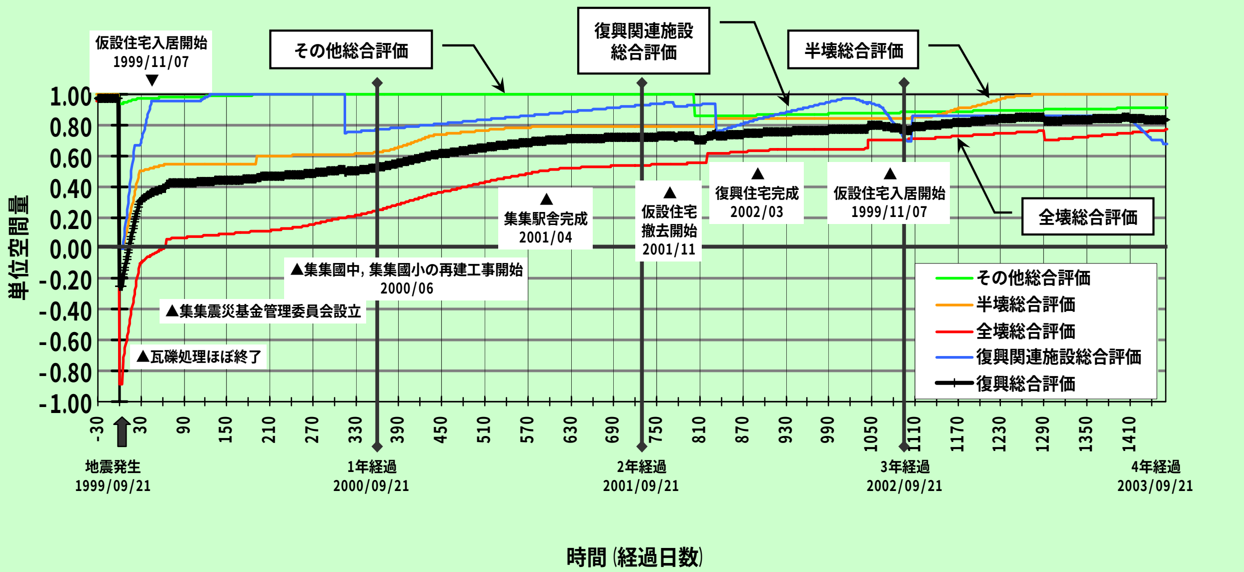


OMS

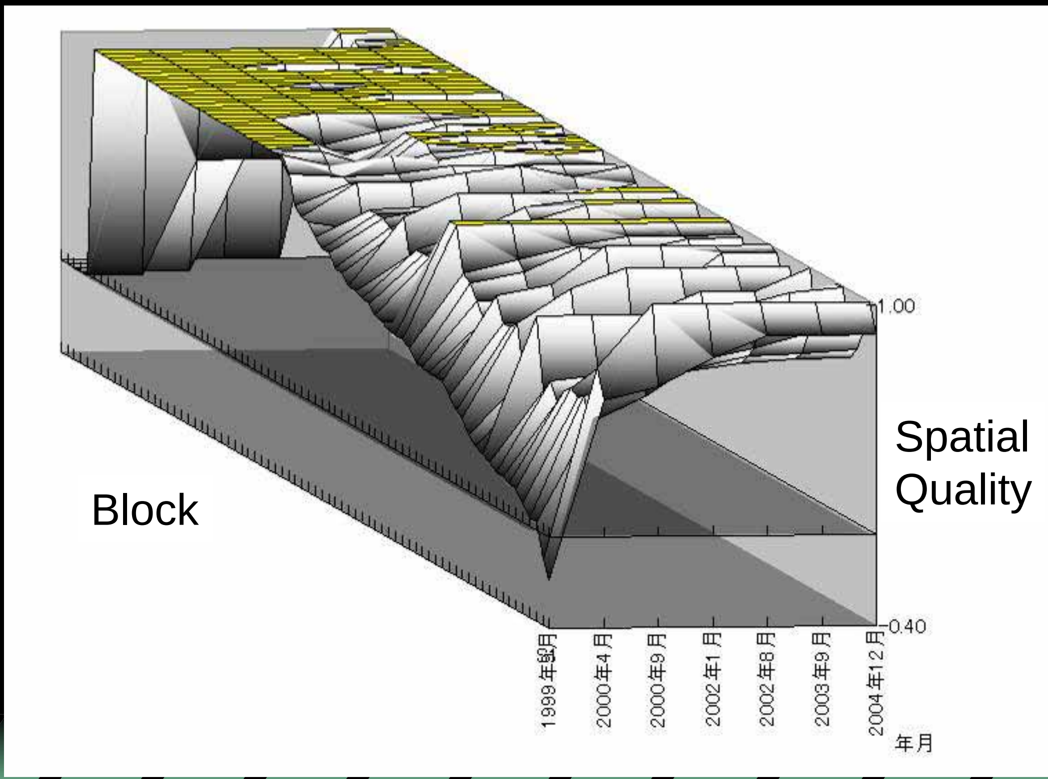
2005年9月 (6年経過)



公共空間の空間復興モデル (空間単位量)



空間復興立体モデル



集集の街並みと復興の記録媒体として

作成過程

1. ベースマップの作成
2. 建物壁面の撮影
3. 撮影画像の処理
4. SketchUp を用いた3 次元空間の創出
5. テクスチャーの貼り付け
6. 復興過程関連情報の挿入

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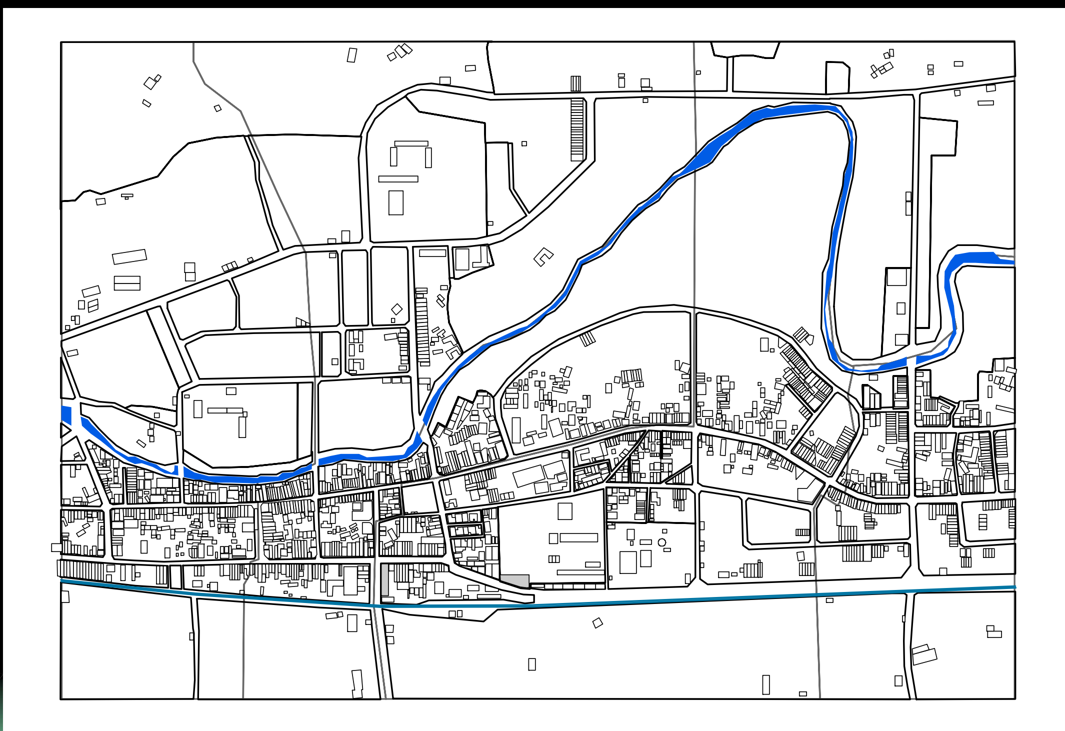
Base map of the Chi-Chi Township created by GIS (Murao, 2006b)



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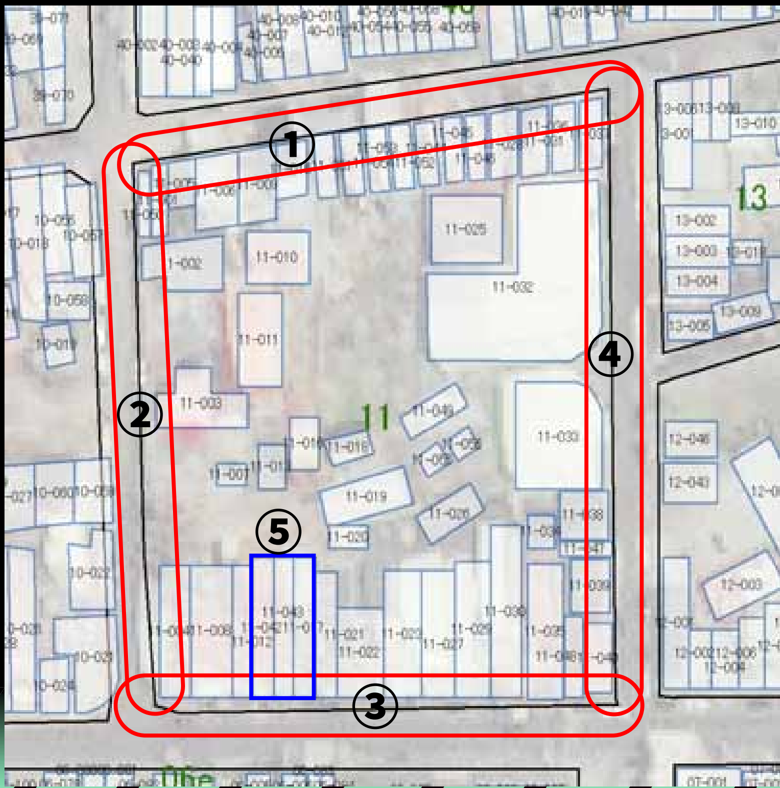
Counterclockwise Order to Photograph



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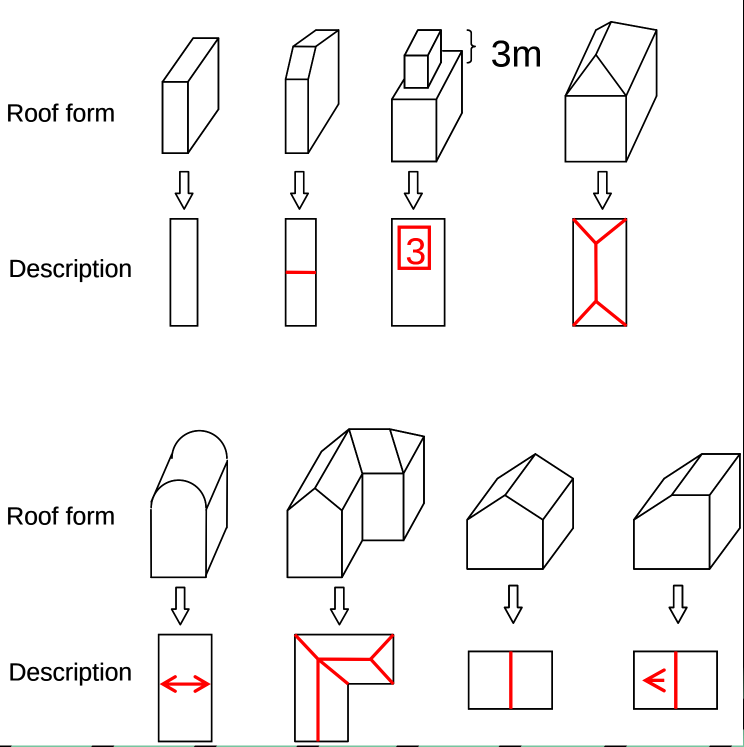
Recording Roof Form

How to record the roof form in Chi-Chi



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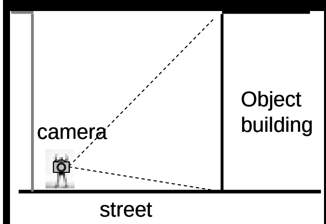
Examples of the Building Façade

Correction of the Building Façade Images Photographed at the Site



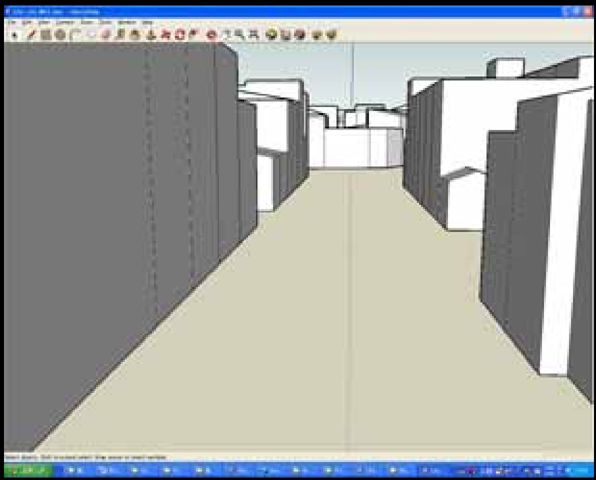
(a) photograph taken at the site

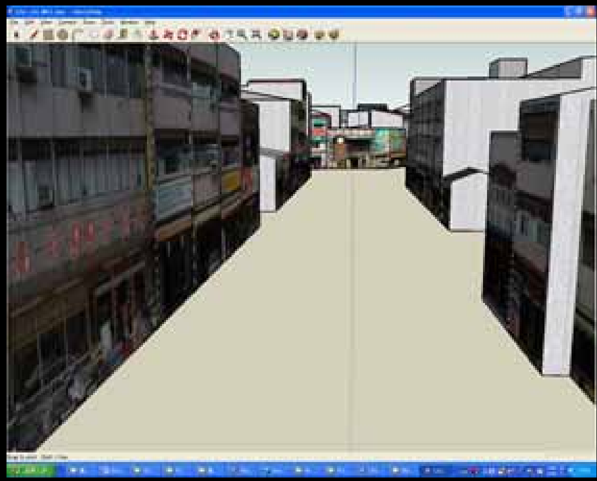
(b) processed image

Elevation Image of the Cluster of the Buildings as Seen from a Street

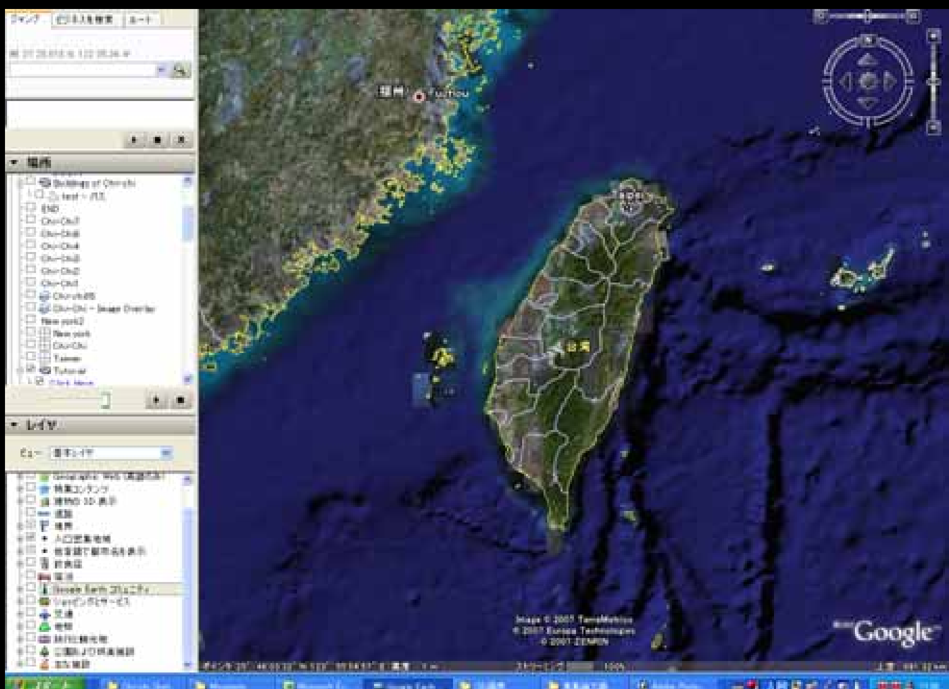
Application of the Elevation Photographs as Textures to the Building Frames

Example of the buildings in the virtual space with exterior walls and roofs (before and after applying the texture)

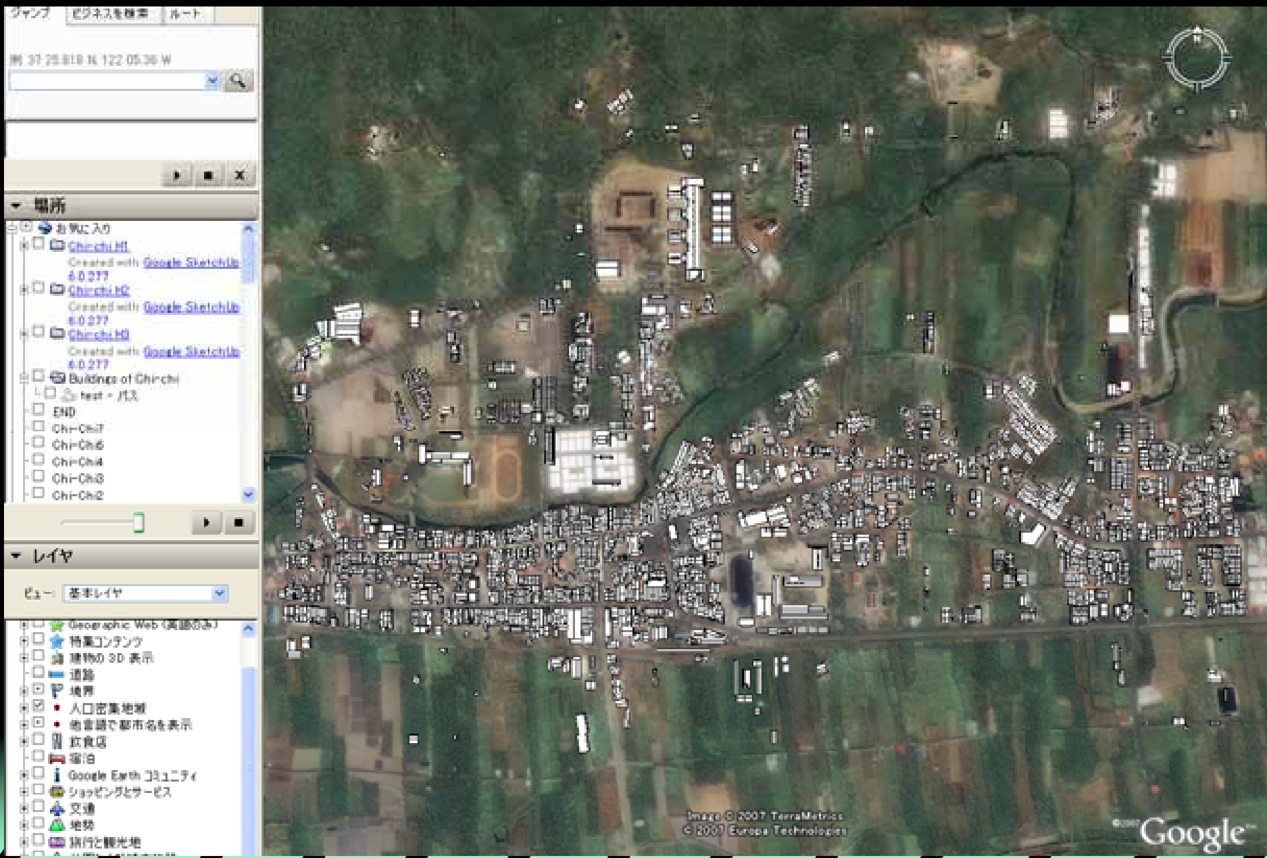


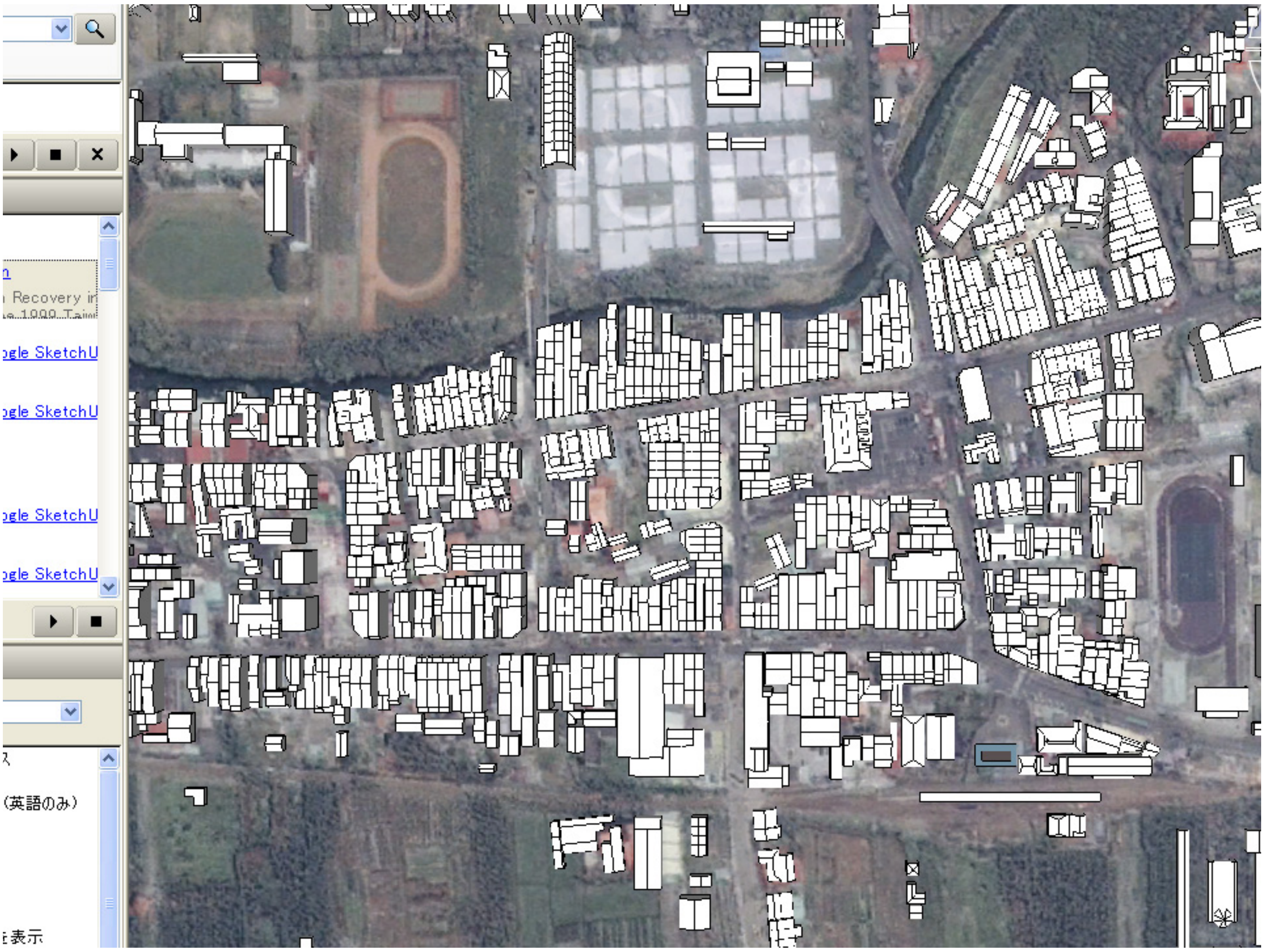


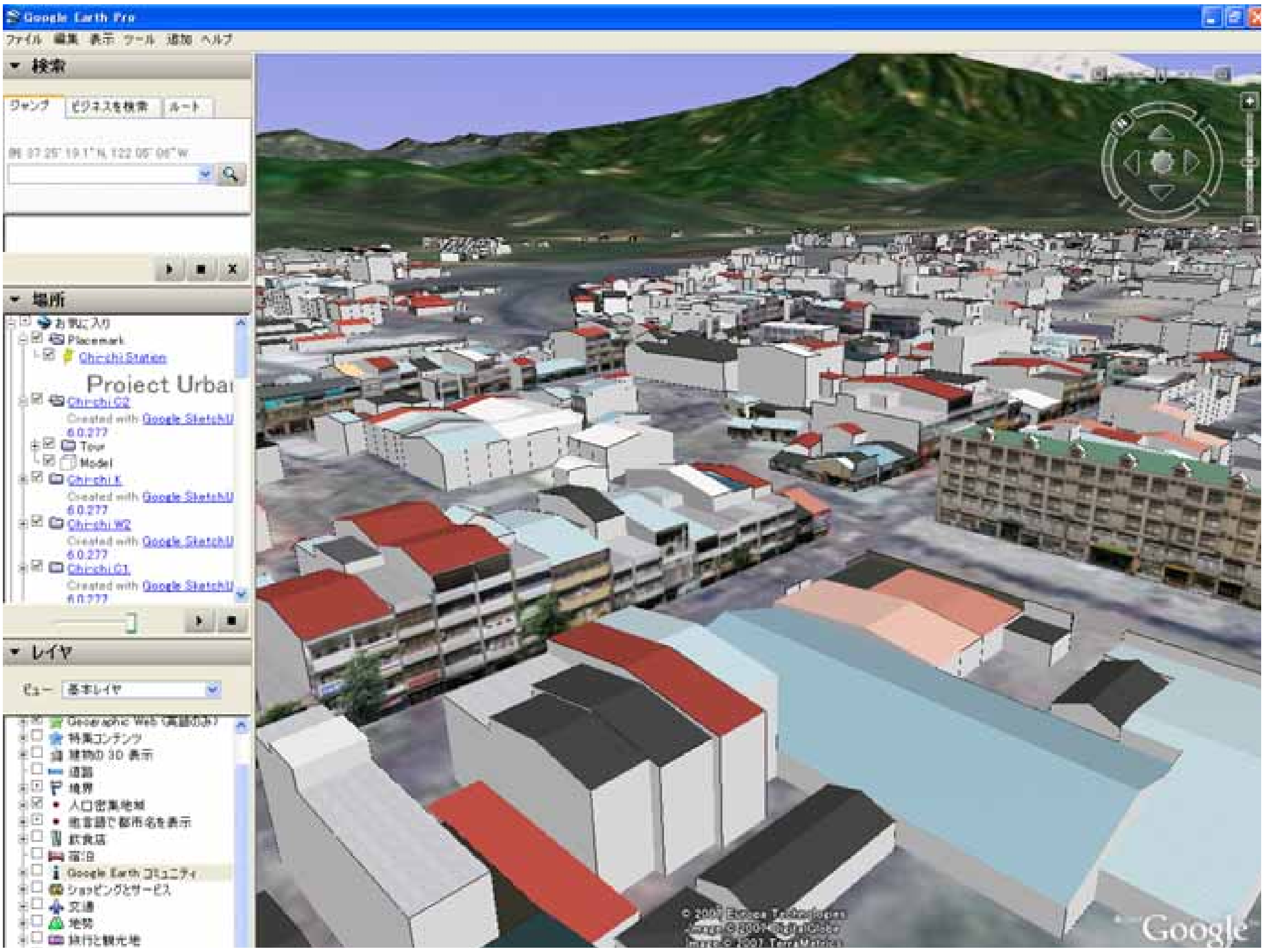
Landscape of Taiwan on GoogleEarth



Position of the district on GoogleEarth

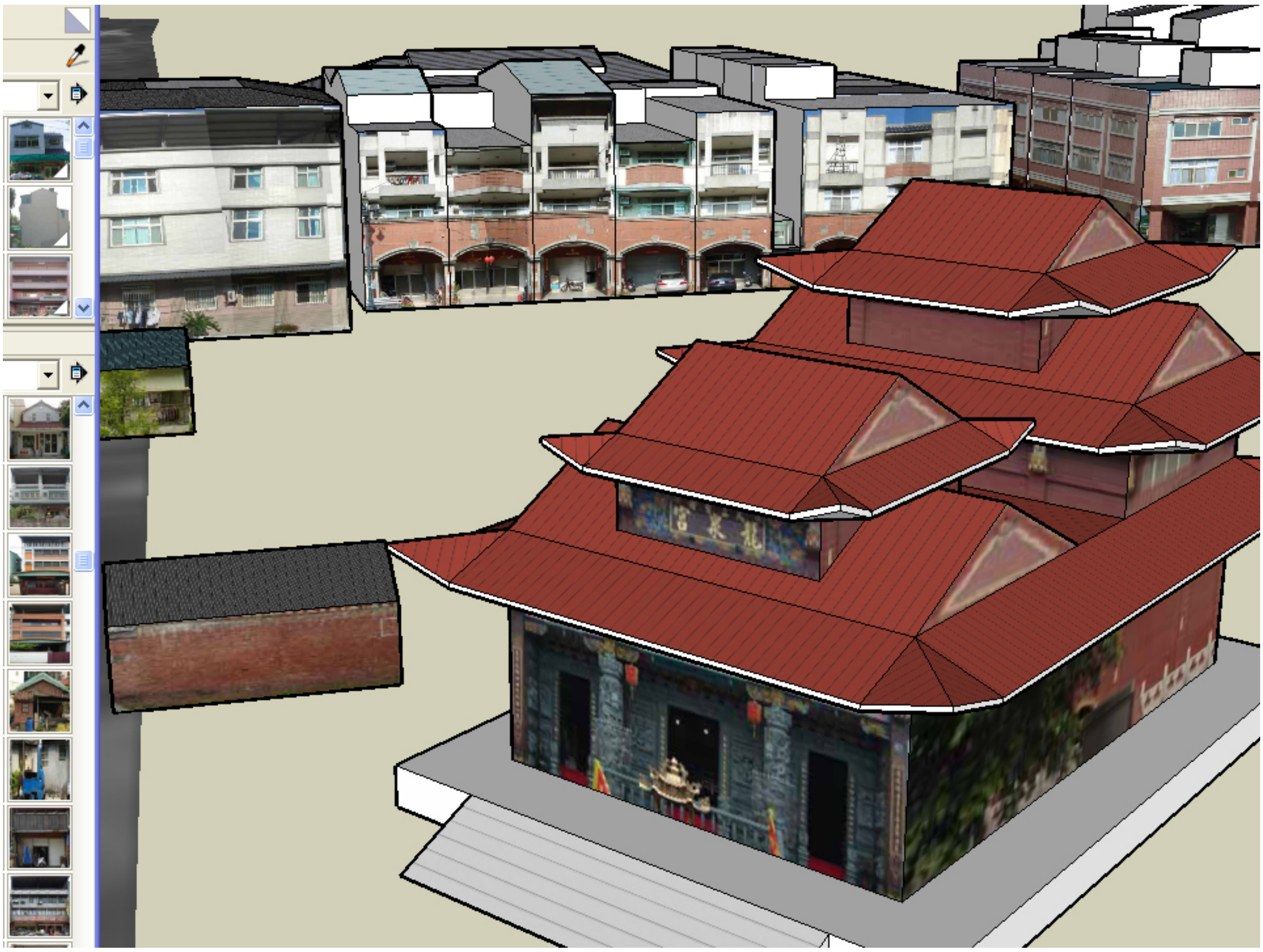


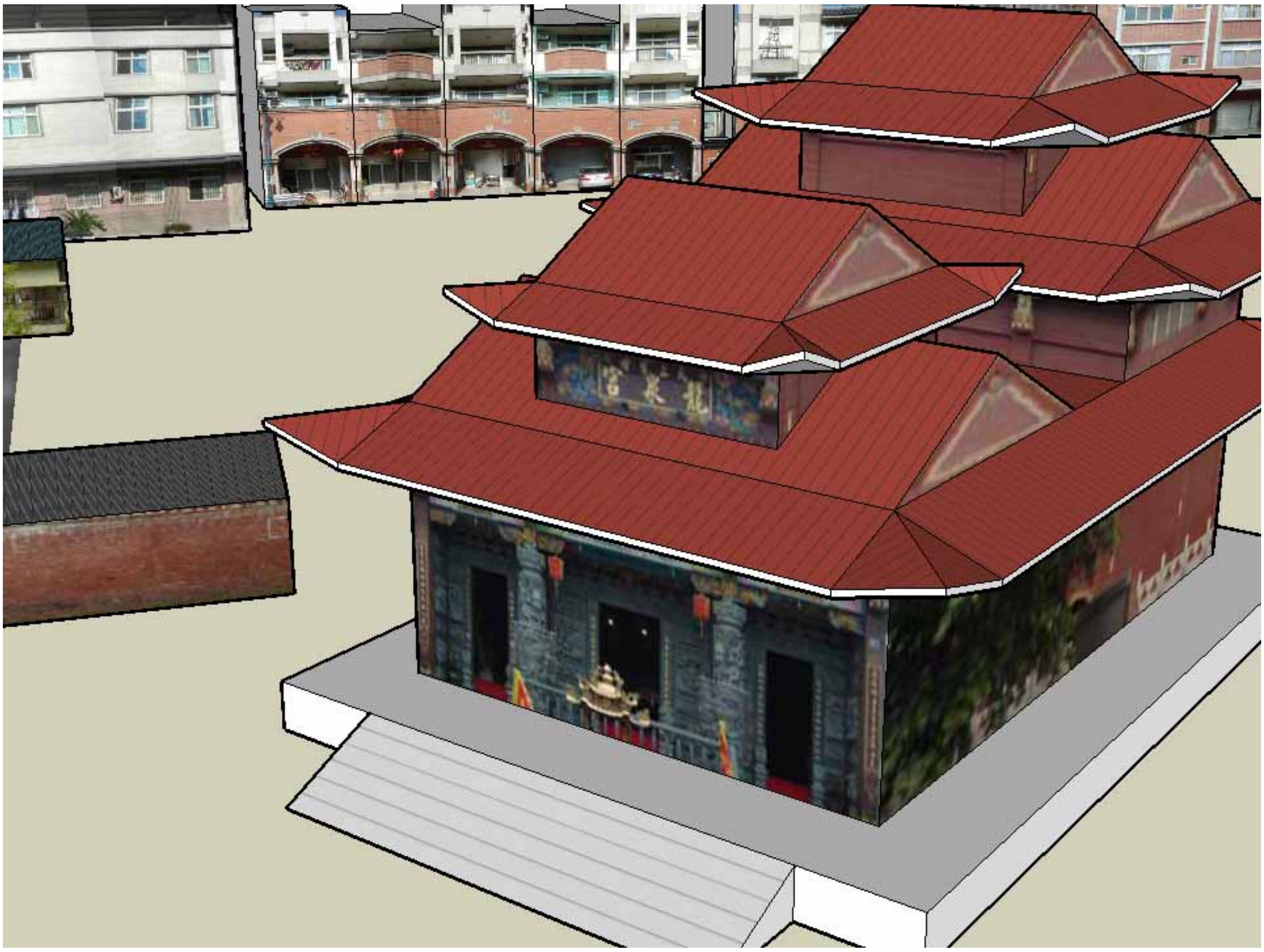


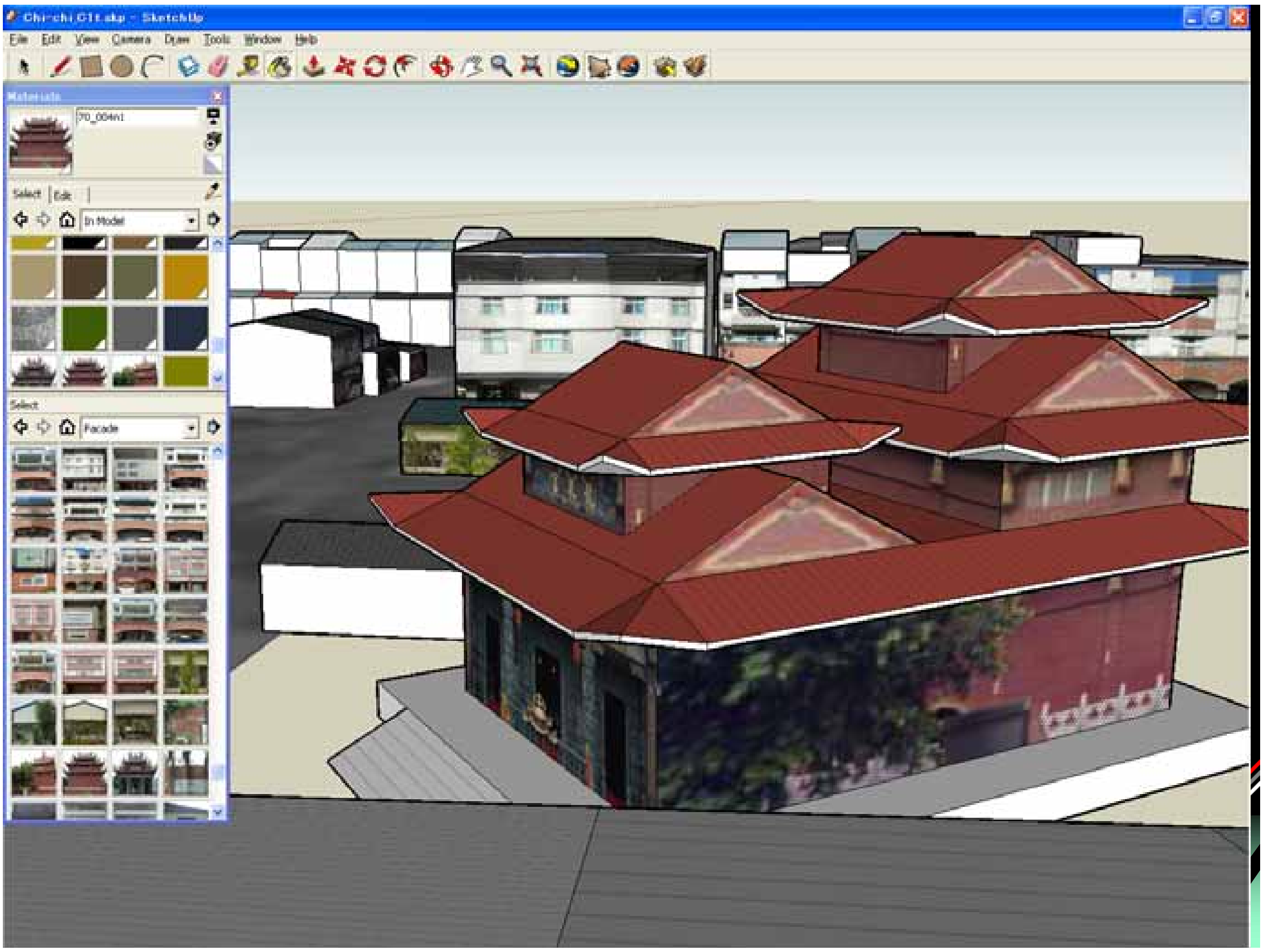

Google Earth Pro
ファイル 編集 表示 ツール 追加 ヘルプ
検索
ジャンプ
ビジネスを検索
ルート
場所
お気に入り
Placemark
Chi-chi Station
Project Urba
Chi-chi G2
Created with Google SketchU
6.0.277
Tour
Model
Chi-chi K
Created with Google SketchU
6.0.277
Chi-chi W2
Created with Google SketchU
6.0.277
Chi-chi G1
Created with Google SketchU
レイヤ
ビュー 基本レイヤ
Geographic Web (英語のみ)
特集コンテンツ
建物の 3D 表示
道路
境界
人口密集地域
他言語で都市名を表示
飲食店
宿泊
Google Earth コミュニティ
ショッピングとサービス
交通
地勢
旅行と観光地
Google


(英語のみ)


Overlay
(英語のみ)






Chi-chi_G1t.skp - SketchUp
File Edit View Camera Draw Tools Window Help
Materials
Select Edit
In Model
Select
Facade

Example of the information regarding to the reconstruction processes that can be displayed on GoogleEarth

Contents	Information Classification
Location of the facilities	description by Placemark
Explanation of the facilities	text
Image of the reconstruction process	image
Result of the analysis of the reconstruction process	graph, table, data, etc.

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ID	Facilities	Structure (The Number of Stories) (Before the	Date of Construction Start	Date of Construction Completion
01	Chi-Chi Sightseeing Center	Parking Lot	2001/12/1	2006/8/31 Unfinished
02	He-Ping National Primary School	RC (2F)	1999/9/26	2000/4/27
03	Chi-Chi Government Office	RC (4F)	2000/4/22	2002/10/15
04	Chi-Chi Health Center	RC (2F)	2003/4/4	2004/summer
05	The First Market	RC (3F)	2002/10/30	2004/summer
06	Chi-Chi Station	Wooden (1F)	2000/4/21	2000/7/24
07	Railroad Musium	Wooden (1F)	2002/1/2	2002/3/8
08	Chi-Chi Resort Center	RC (5F)	2000/12/27	2001/12/31
09	Chi-Chi Public Swimming Pool	-	2000/4/9	2002/11/22
10	Parking Lot	RC (B2F)	1997/7/9	2001/1/17
11	Chi-Chi Police Station	RC (3F)	2002/8/10	2004/summer
12	Chi-Chi Nationarl Junior High School	RC (2F)	2000/6/1	2000/12/1
13	Chi-Chi Nationarl Primary School	RC (2F)	2000/6/1	2001/3/1
14	Farmer Bank	RC (3F)	-	2001/12/19
15	Wu-Chang Temple	RC (3F)	1999/11/1	Preserved
16	Guang-Sheng Temple	Wooden (1F)	2000/7/1	2003/8/1
17	Temporary Housing (I) (138+20)	–	1999/10/20	2000/1/28
18	Temporary Housing (II) (72)	–	1999/9/26	1999/10/13
19	Temporary Housing (III) (23)	–	1999/9/26	1999/10/13
20	Permanent Housing constructed by Chi-Chi Governmen	–	2000/8/1	2002/3/1

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Example of displaying the information regarding
the reconstruction process
using the placemark function

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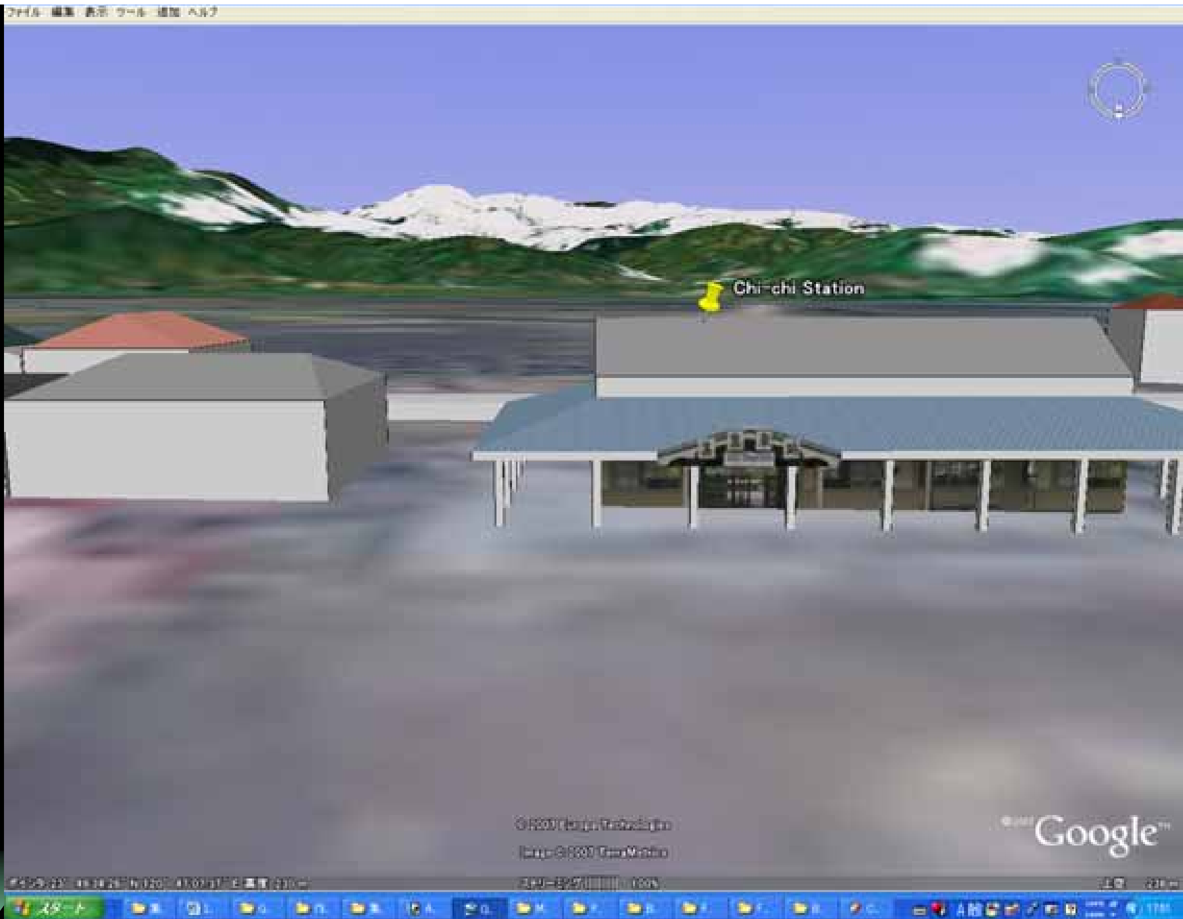

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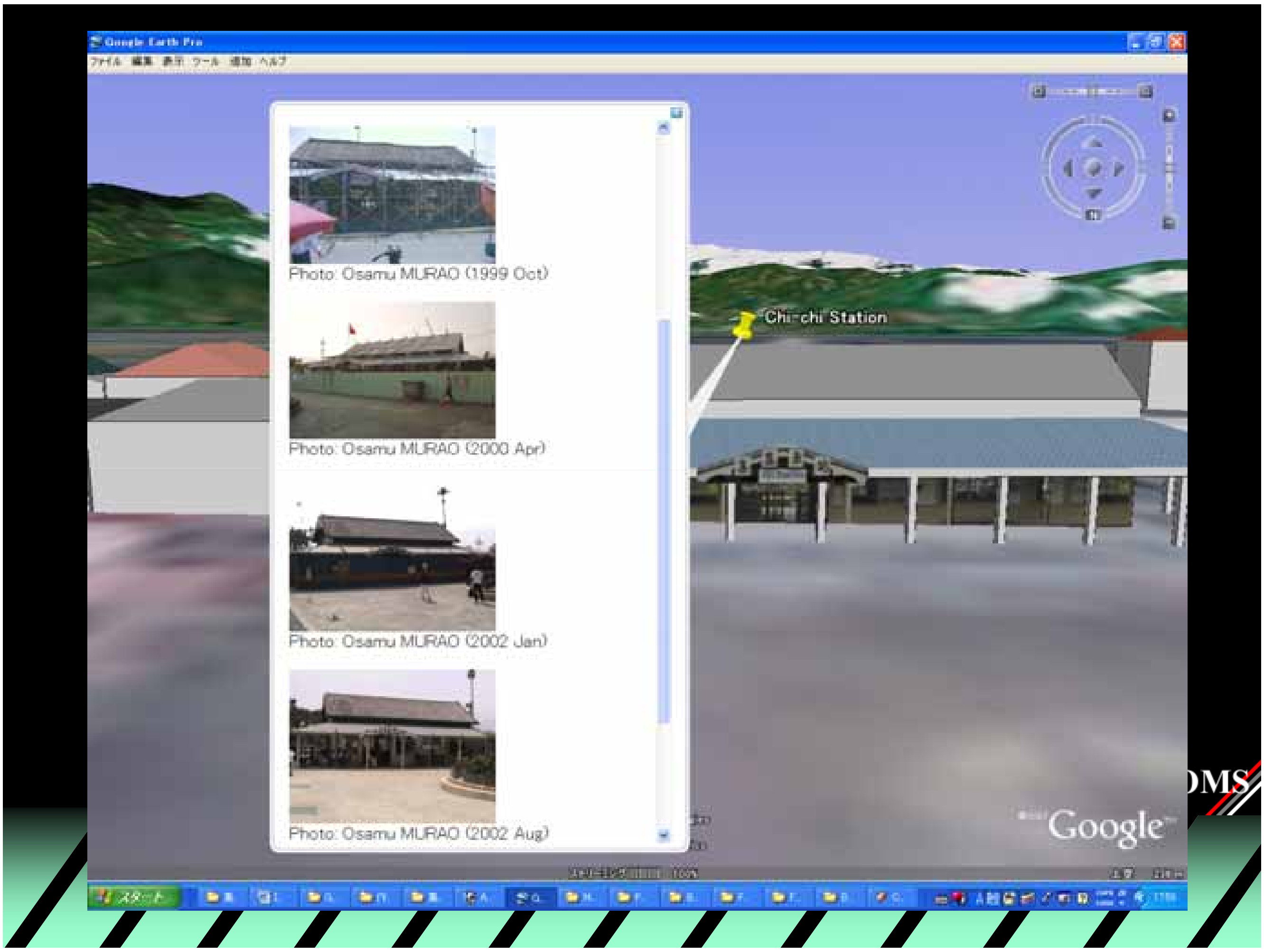
Google Earth Pro
ファイル 編集 表示 ツール 追加 ヘルプ
Photo: Osamu MURAO (1999 Oct)
Photo: Osamu MURAO (2000 Apr)
Photo: Osamu MURAO (2002 Jan)
Photo: Osamu MURAO (2002 Aug)
Chi-chi Station
Google


Google Earth Pro
ファイル 編集 表示 ツール 追加 ヘルプ
検索
場所
レイヤ
Chi-chi Station
Project Urban Recovery in the World
Project01: The 1999 Taiwan Earthquake
001 Chi-Chi Station
1999 September
2000 April
2000 July
This station is the most famous landmark in Chi-Chi known as Japanese wooden style architecture. It was built in 1933 under Japanese rule and cypress was used for building material. After the damage due to the earthquake, it was reconstructed in July 2000.
Photo: Osamu MURAO (1999 Oct)

Google Earthを用いた集集復興デジタルアーカイブ

完

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Speed Detection for Moving Objects from Digital Aerial Camera and QuickBird Sensors

September 2007

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2. National Institute of Advanced Industrial Science and Technology, Tsukuba, Japan.

Background

- Satellite remote sensing and aerial photography have been used to capture **still** (snapshot) images of the earth surface.
- But if **two images** with a **small time interval** are taken, they can be employed to **detect moving objects**, e.g. cars, and even measure their **speeds**.
- If such data are available, many **new applications** can be considered such as **observing highway traffic conditions**.

Objectives

- Demonstrate the possibility and limitation of detecting moving objects from a **QuickBird** (QB) scene using a slight time lag (=0.2 seconds) between panchromatic (PAN) and multi-spectral (MS) sensors.

- Develop a **new object-based method** to extract moving vehicles and subsequently detect their speeds from two consecutive **aerial images** automatically.

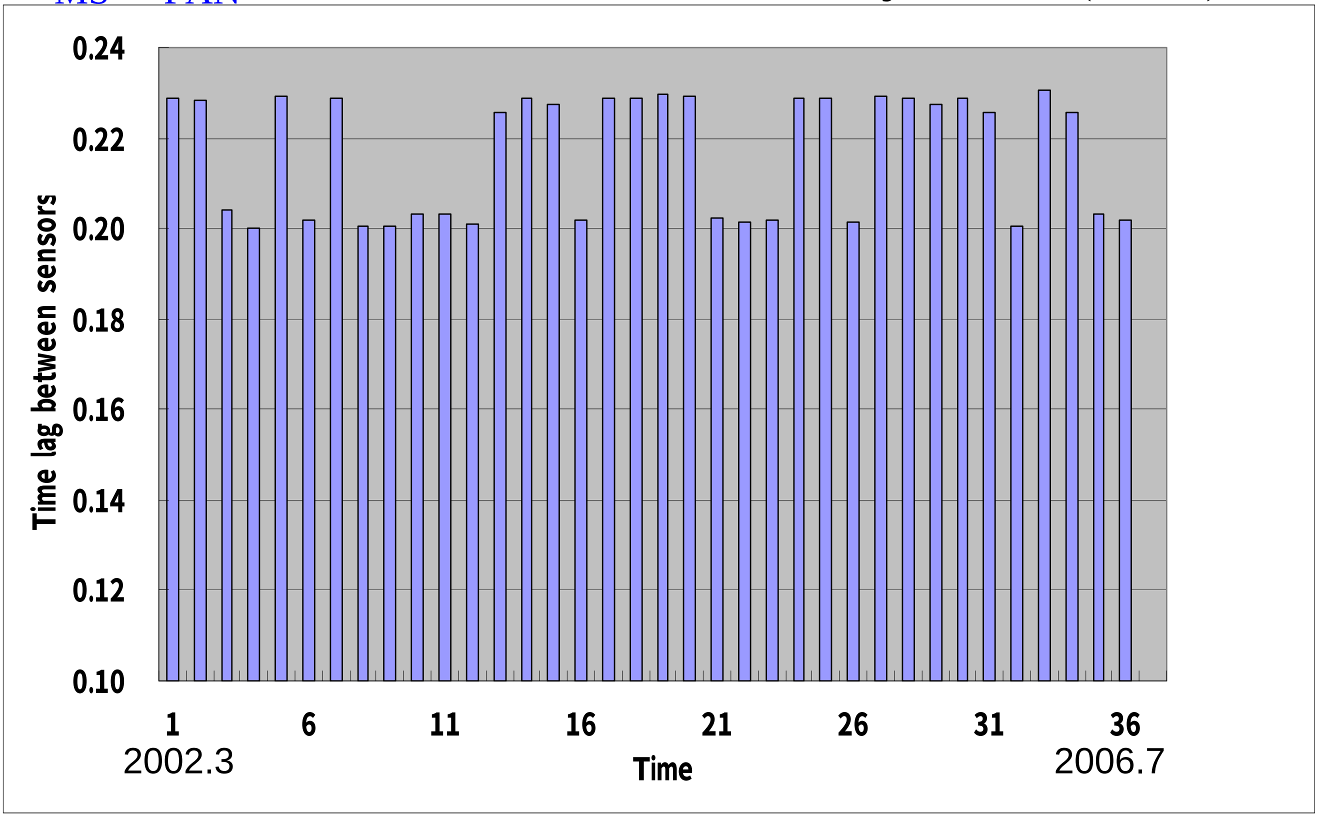
Contents

- Time lag in QB images and moving objects seen in Google Earth
- Visual inspection of vehicle speed from QB images
- Detection of vehicle speed from digital aerial images
- Automated detection of vehicles from aerial images

Time Lag between PAN and MS sensors of QuickBird

Images from Japan, USA, Peru, Thailand, Indonesia, Morocco, Iran, Turkey, Algeria

T_{MS}-T_{PAN}=Δt = 0.20s or 0.23s as Etaya et al. (2004)

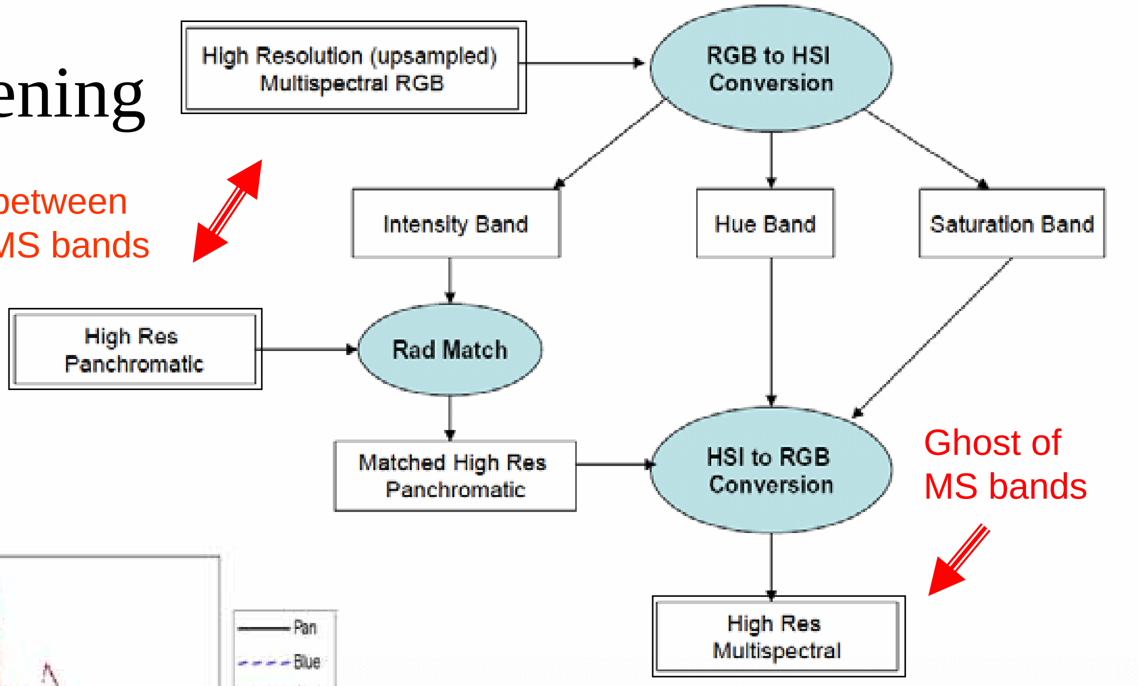


QuickBird Images with PAN and MS

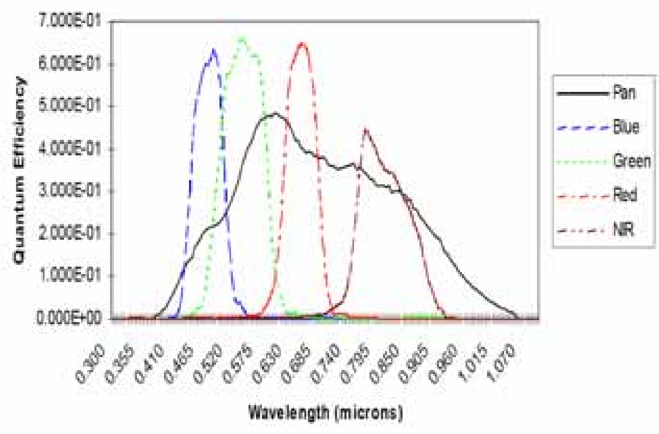
City	Country	Pan Date	Pan second	Multi second	Time lag	Angle
Phuket	Thailand	2002-03-23T04:01:03.062201Z	3.062201	3.290829	0.228628	18.7
Bourmerdes	Algeria	2002-04-22T10:38:03.511477Z	3.511477	3.739662	0.228185	11.2
Nazca	Peru	2002-09-16T15:17:21.362451Z	21.362451	21.566609	0.204158	7.9
Bangkok	Thailand	2002-11-07T03:53:50.219099Z	50.219099	50.419314	0.200215	12.4
Ho Chi Minh	Vietham	2003-01-24T03:23:00.199687Z	0.199687	0.428753	0.229066	5.8
Al Hoceima	Morocco	2003-05-02T10:52:47.103698Z	47.103698	47.305407	0.201709	9.9
Al Hoceima	Morocco	2003-05-02T10:52:48.132006Z	48.132006	48.360933	0.228927	9.9
Zemmouri	Algeria	2003-05-13T10:26:11.716533Z	11.716533	11.917026	0.200493	8.7
Zemmouri	Algeria	2003-05-13T10:26:11.982056Z	11.982056	12.182562	0.200506	9.9
Zemmouri	Algeria	2003-05-23T10:36:02.233942Z	2.233942	2.437080	0.203138	24.4
El Bahri	Algeria	2003-05-23T10:36:02.245295Z	2.245295	2.448350	0.203055	24.4
Bourmerdes	Algeria	2003-05-23T10:36:02.997635Z	2.997635	3.198562	0.200927	24.4
Zemmouri	Algeria	2003-06-13T10:20:07.060596Z	7.060596	7.286107	0.225511	15.7
Bourmerdes	Algeria	2003-06-13T10:20:07.832587Z	7.832587	8.061467	0.228880	15.7
El Bahri	Algeria	2003-06-18T10:25:17.237030Z	17.237030	17.464350	0.227320	7.8
Bourmerdes	Algeria	2003-06-18T10:25:17.867547Z	17.867547	18.069401	0.201854	7.8
Golcuk	Turkey	2003-07-09T08:34:57.832288Z	57.832288	58.061186	0.228898	24.3
Java	Indonesia	2003-07-11T02:53:46.114738Z	46.114738	46.343444	0.228706	5.9
Java	Indonesia	2003-07-11T02:53:46.126404Z	46.126404	46.356200	0.229796	6.6
Bam	Iran	2003-09-30T06:36:37.696921Z	37.696921	37.925953	0.229032	10.2
Bam	Iran	2003-09-30T06:36:38.315425Z	38.315425	38.517892	0.202467	10.2
Bam	Iran	2004-01-03T06:43:10.872776Z	10.872776	11.074393	0.201617	23.6
Bam	Iran	2004-01-03T06:43:11.086528Z	11.086528	11.288208	0.201680	24.7
Al Hoceima	Morocco	2004-04-21T10:53:54.115946Z	54.115946	54.344776	0.228830	10.2
Al Hoceima	Morocco	2004-04-21T10:53:54.451403Z	54.451403	54.680398	0.228995	9.7
Al Hoceima	Morocco	2004-04-21T10:53:55.104604Z	55.104604	55.306103	0.201499	9.7
Niigata	Japan	2004-10-24T01:14:13.736939Z	13.736939	13.965948	0.229009	47.0
Niigata	Japan	2004-10-24T01:14:15.869887Z	15.869887	16.098831	0.228944	46.9
Niigata	Japan	2004-10-24T01:14:16.178797Z	16.178797	16.406078	0.227281	47.0
Niigata	Japan	2004-10-24T01:14:18.243454Z	18.243454	18.472351	0.228897	46.8
Phuket	Thailand	2005-01-02T04:12:41.455673Z	41.455673	41.681230	0.225557	27.3
Katrina	USA	2005-09-03T16:59:44.549076Z	44.549076	44.749734	0.200658	8.2
Java	Indonesia	2006-06-08T03:09:30.290380Z	30.290380	30.520786	0.230406	42.9
Java	Indonesia	2006-06-13T03:14:21.660828Z	21.660828	21.886511	0.225683	25.3
Java	Indonesia	2006-06-13T03:14:24.784328Z	24.784328	24.987395	0.203067	26.5
Java	Indonesia	2006-07-11T03:25:44.101285Z	44.101285	44.303326	0.202041	15.6

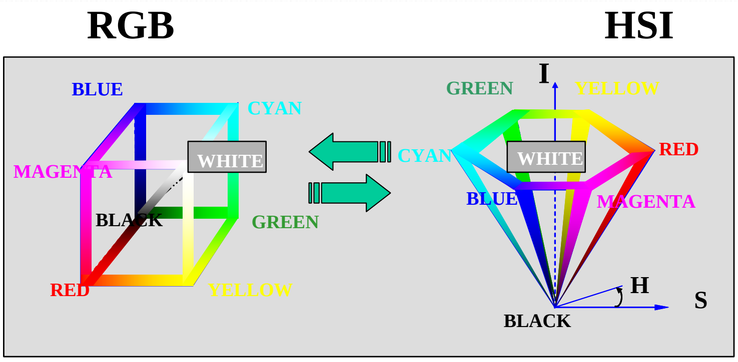
HIS Pansharpening

Time lag between
Pan and MS bands



Ghost of
MS bands





Pansharpened QuickBird Image from Google Earth

Tokyo/Narita International Airport, Japan

just take-off

Δl=17.8 m

$v= \Delta l/\Delta t$

=17.8/0.2 =89 m/s = 320 km/h

Pansharpened QuickBird Image from Google Earth
Manila International Airport, Philippines

just landing

Δl=18.1 m

v=18.1/0.2=90.5 m/s = 326 km/h

Pansharpened QuickBird Image from Google Earth
Hong Kong International Airport, China

After take-off

Δl=22.1 m

v=22.1/0.2=110.5 m/s = 398 km/h

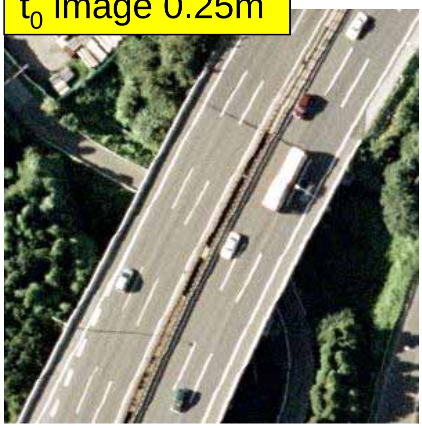
Pansharpened QuickBird Image from Google Earth
Shinkansen train near **Toyohashi**, Japan

Pansharpened QuickBird Image from Google Earth
Sky-train in central **Bangkok**, Thailand

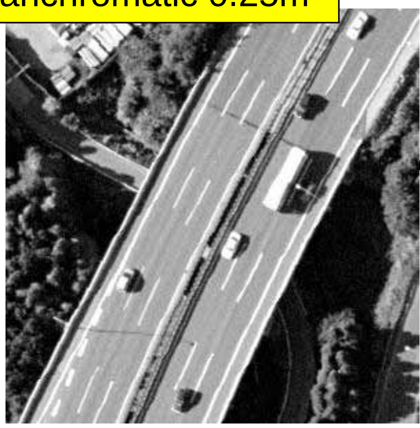
Pansharpened QuickBird Image from Google Earth
Tokyo-Nagoya Expressway near Isehara, Japan

Simulated Pansharpened Image Having Small Time-Lag between Panchromatic and Multi-spectral Sensors

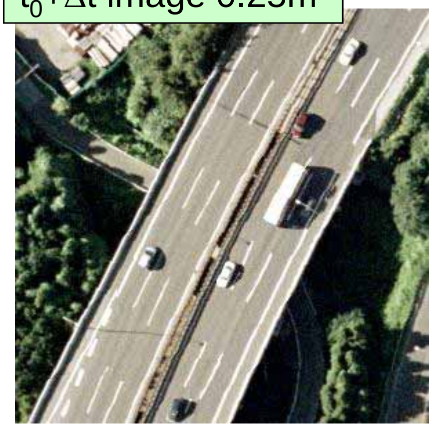
t_0 image 0.25m



Panchromatic 0.25m



$t_0+\Delta t$ image 0.25m



Multispectral 1.0m

Simulated
Pansharpened 0.25m

Ghosts appeared in front of cars.

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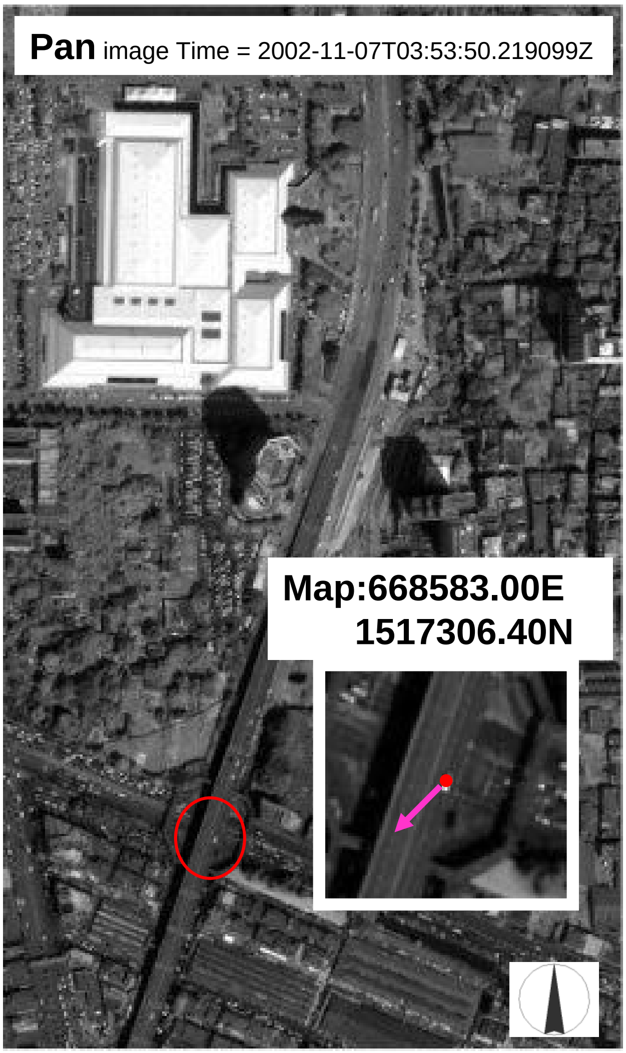


QB bundle product of Bangkok

S: $s_E = 668580.00_{(MS)} - 668583.00_{(Pan)} = -3.00m$

$s_N = 1517304.00_{(MS)} - 1517306.40_{(Pan)} = -2.40m$

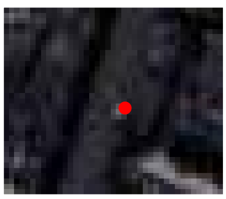
$S^2 = s_E^2 + s_N^2 = 3.84m$

T: $t = 50.419314_{(MS)} - 50.219099_{(Pan)}$ $0.20s$

v: $v = ds/dt = 3.84/0.20$

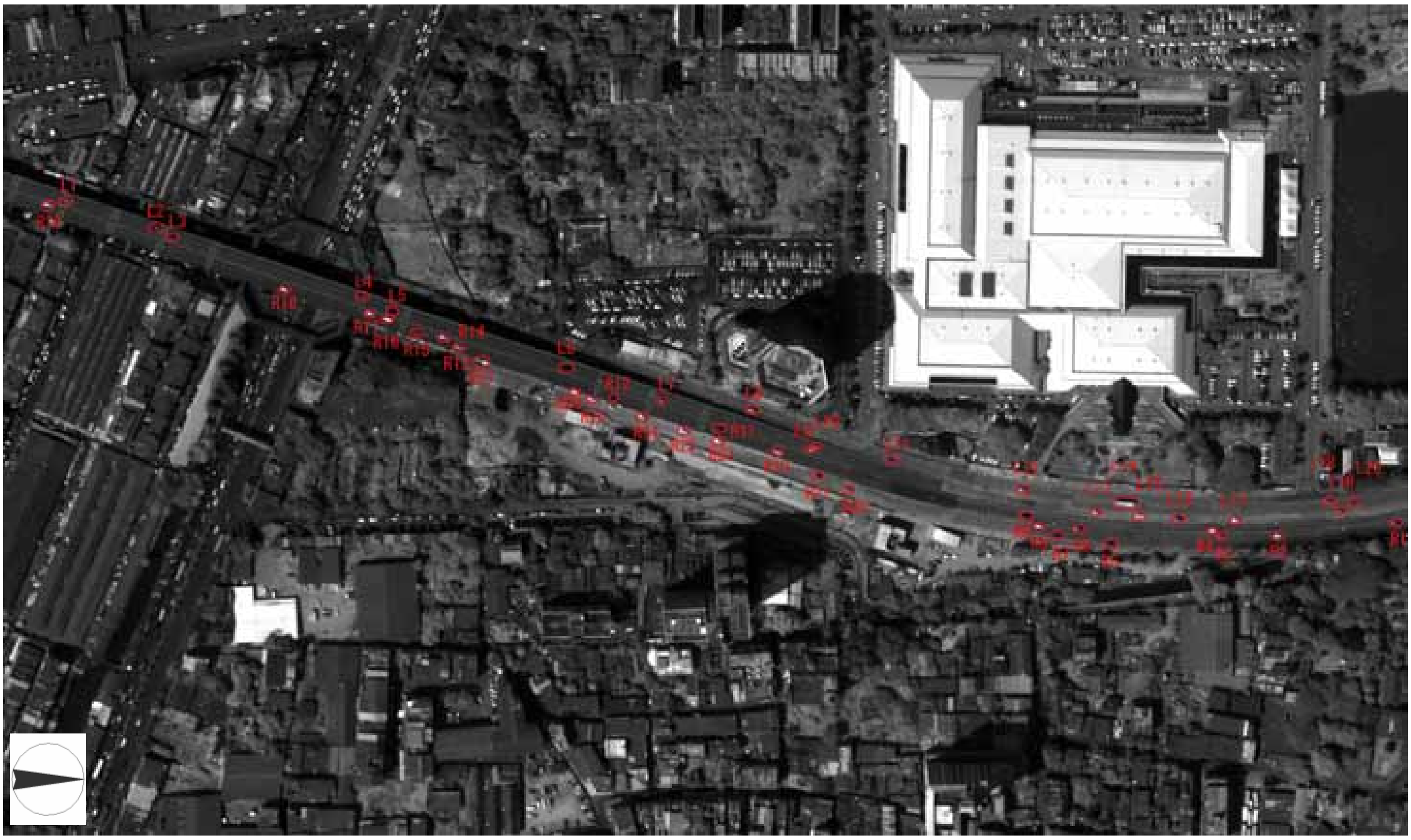
$= 19.2\ m/s = 69.1 km/h$

MS image Time = 2002-11-07T 03:53:50.419314Z1



Map:668580.00E
1517304.00N

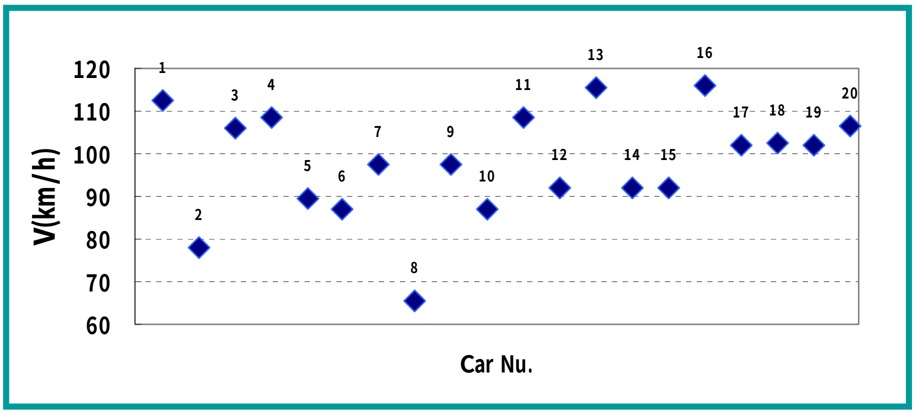
Up: North bound L1~L20 (from left)



Down: South bound R1~R27 (from right)

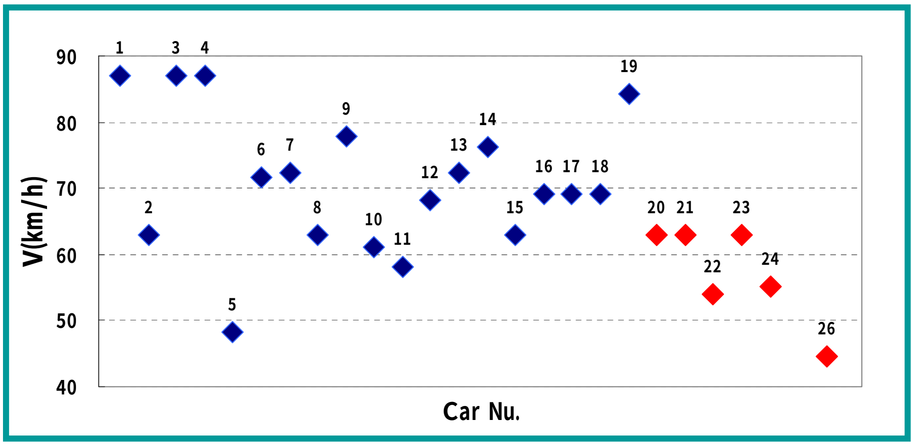
Visual inspection results

North bound lanes



- ◆60km/h < v < 120km/h
- ◆V $_{average}$ =97.93km/h

South bound lanes



◆R1~R19:

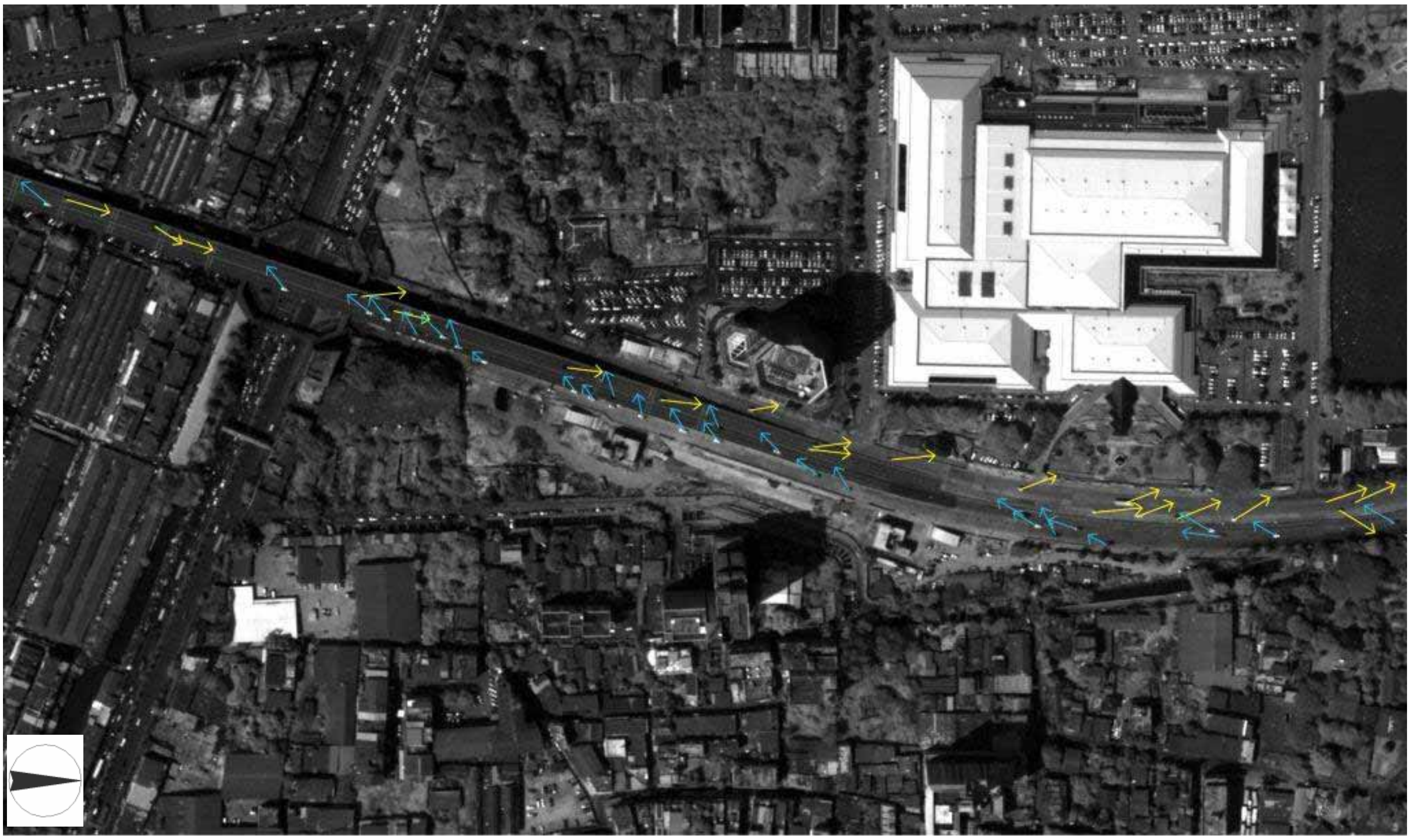
45km/h<v<90km/h

v $_{average}$ =70.92km/h

◆R20~R27:

The speed is reduced as the cars close to the crossroad.

Result of visual speed detection



The length of the arrows ∝ the speed

The arrow directions mean the car directions

■North bound lanes

■South bound lanes

Test of accuracy using simulated QB images

Carry out tests using simulated QB images produced from aerial images to assess the accuracy of visual inspection.

(use 3 aerial images and move the cars in the images to obtain the second images.)



Miyanogi, Chiba, Japan 02/7/20 from PASCO CORP. 0.25m/pixel

Before

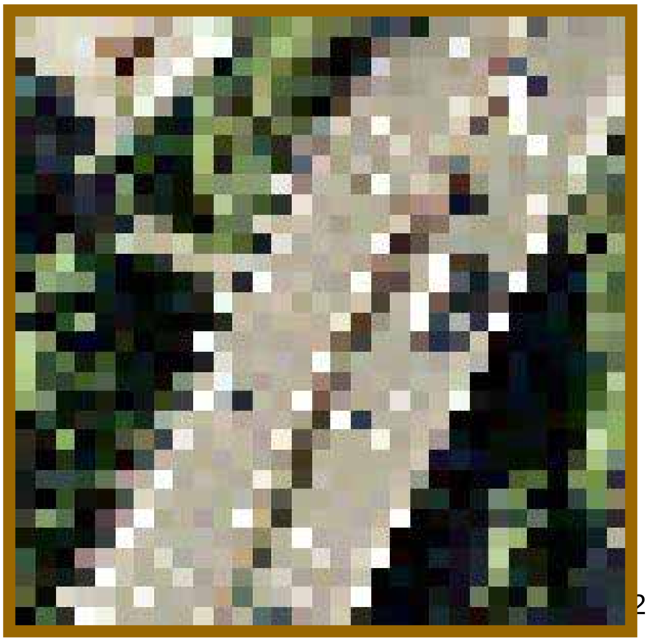
Simulate the Pan image

Pan=(Band1+Band2+Band3)/3

Resize to 0.6m/pixel

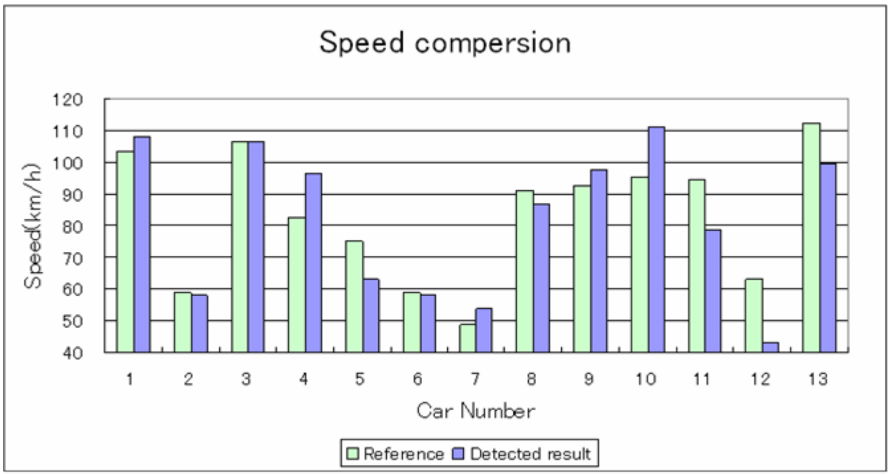
Simulated Pan image

After



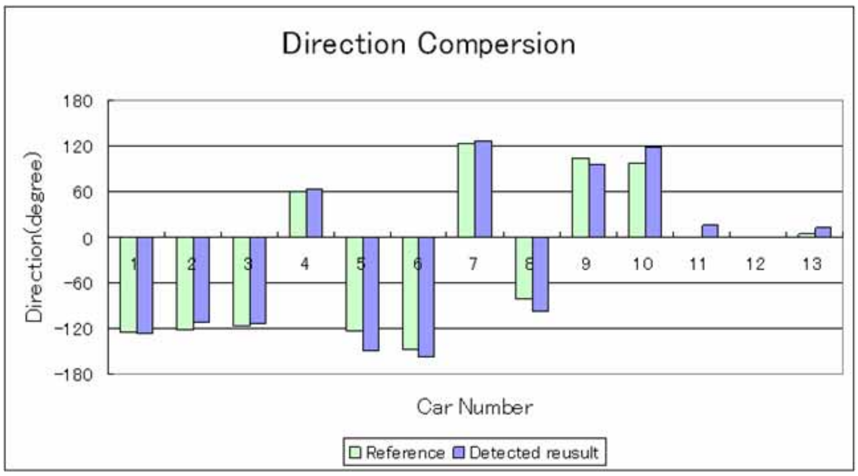
Simulated MS image

Resize to 2.4m/pixel



The standard deviation of the **speed** difference between the reference value and detected results is around 11km/h.

The standard deviation of the **azimuth angle** difference between the reference value and detected results is around 13 degrees.



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Digital Aerial Camera: **UltraCam D**

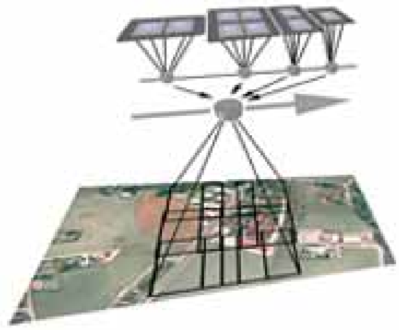
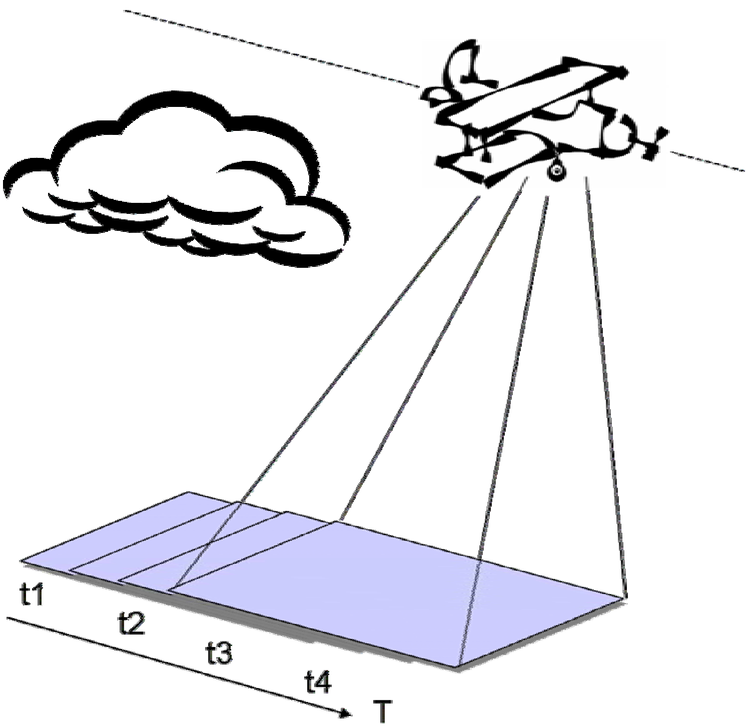


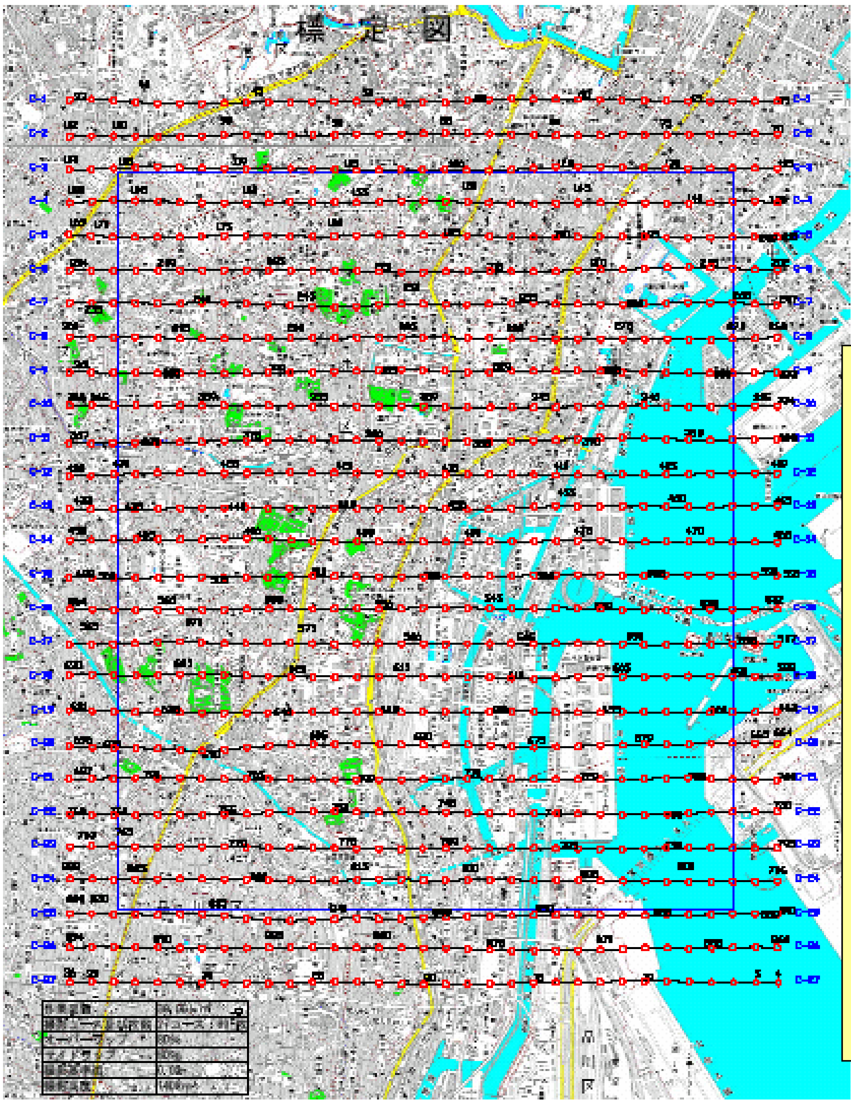
Figure 6: Color image segment from aerial film (left) with a GSD of 15 cm, obtained from a 12.5μm scan. The UltraCam-image has a GSD of 16 cm (right). The inserts are 2x enlarged and have a diameter of 150 pixels. Note the definition of the railroad track.

http://www.pasco.co.jp/measure/air/ultracam/
http://www.vexcel.com/products/photogram/ultracam/index.html

Speed detection of vehicles from aerial images



- **High resolution**.
- Two consecutive aerial images have **60~80% overlap**.
- The **time lag** between two images is **a few seconds**.
- The **speed of vehicles** can be detected with **higher accuracy**.



Flight Lines of Digital Aerial Photography of Tokyo by GSI

UltraCam D

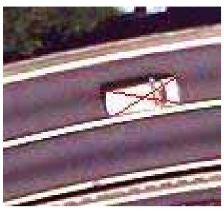
Date: August 4, 2006
Azimuth Overlap: 80%
Lateral overlap: 80%
Flight height: 1,400m

Bands: **B**,**G**, **R**, **NIR**, **Pan**
Pixel size: 9.0 µm (Pan, MS)
Image size:
11500*7500 pixels (Pan)
3680 * 2400 pixels (MS)
Resolution: 12 cm (Pan)
37.5 cm (MS)

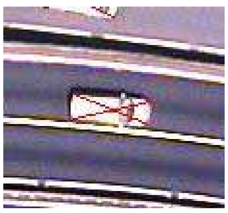
Sharpened Multispectral
True Color Composite

Sharpened Multispectral
False Color Composite

Hamazakibashi, Tokyo 04/8/06 from GSI 0.12m/pixel

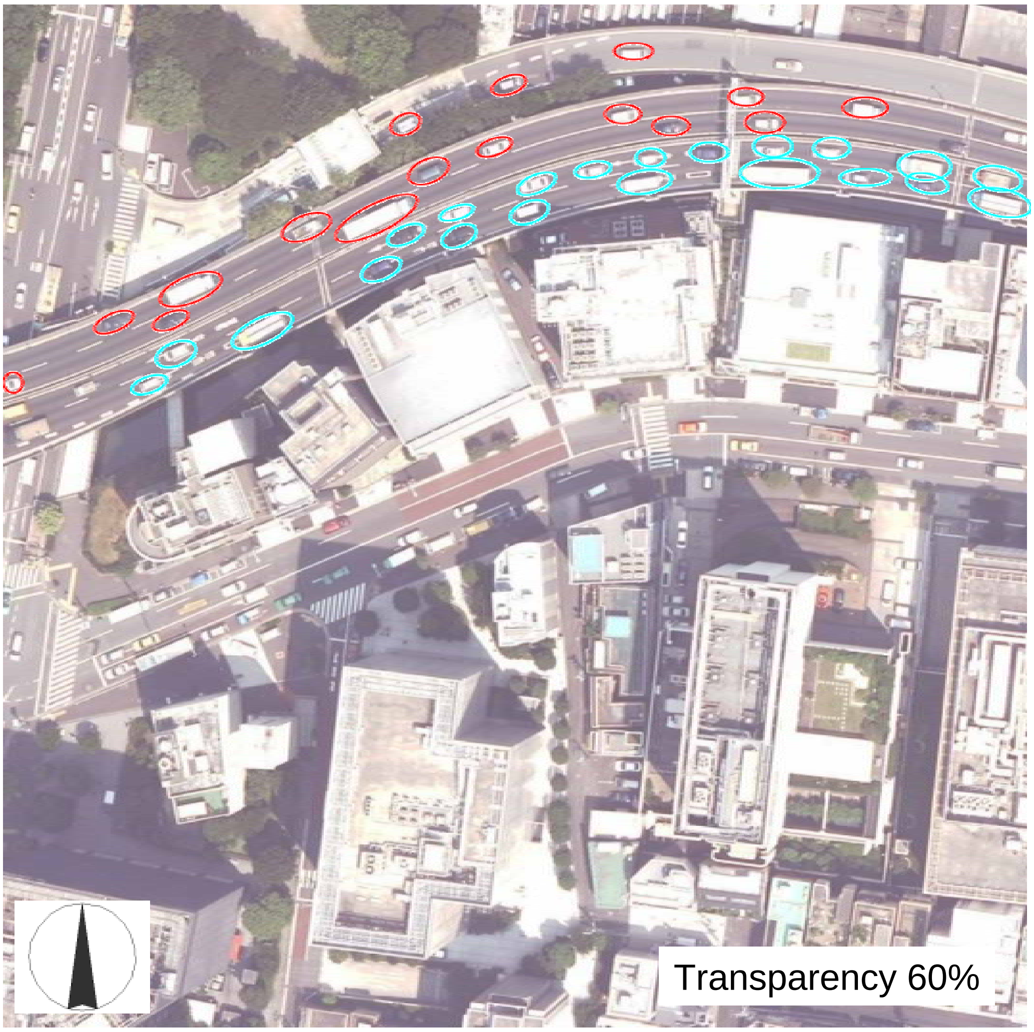


-7507.91W
-38375.49S



-7474.55W
-38358.52S

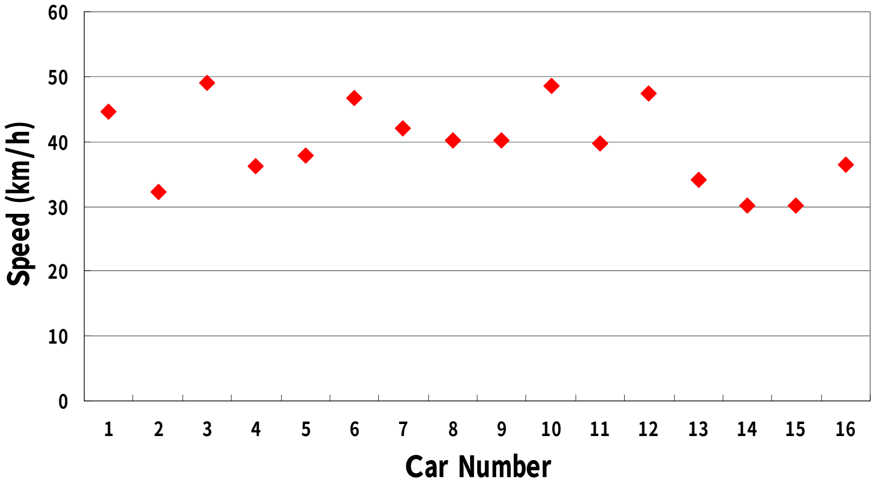
Δt=438383.3394-438380.2618=3.0776 s



The targets in the upper lanes: 16 cars.

The targets in the lower lanes: 21 cars.

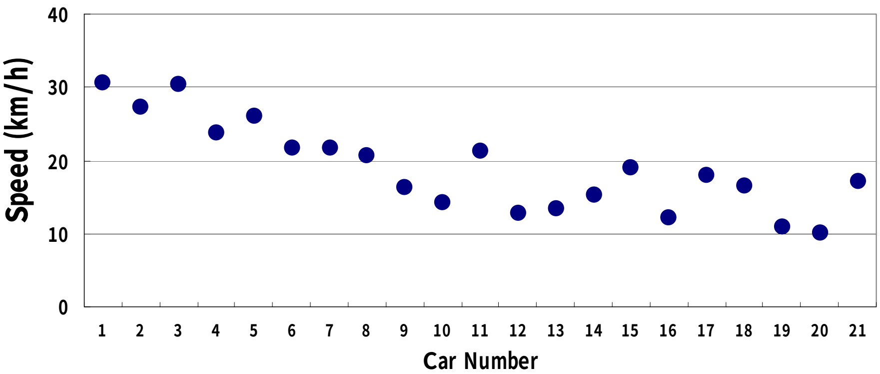
Upper Roadway



30km/h < v < 50km/h

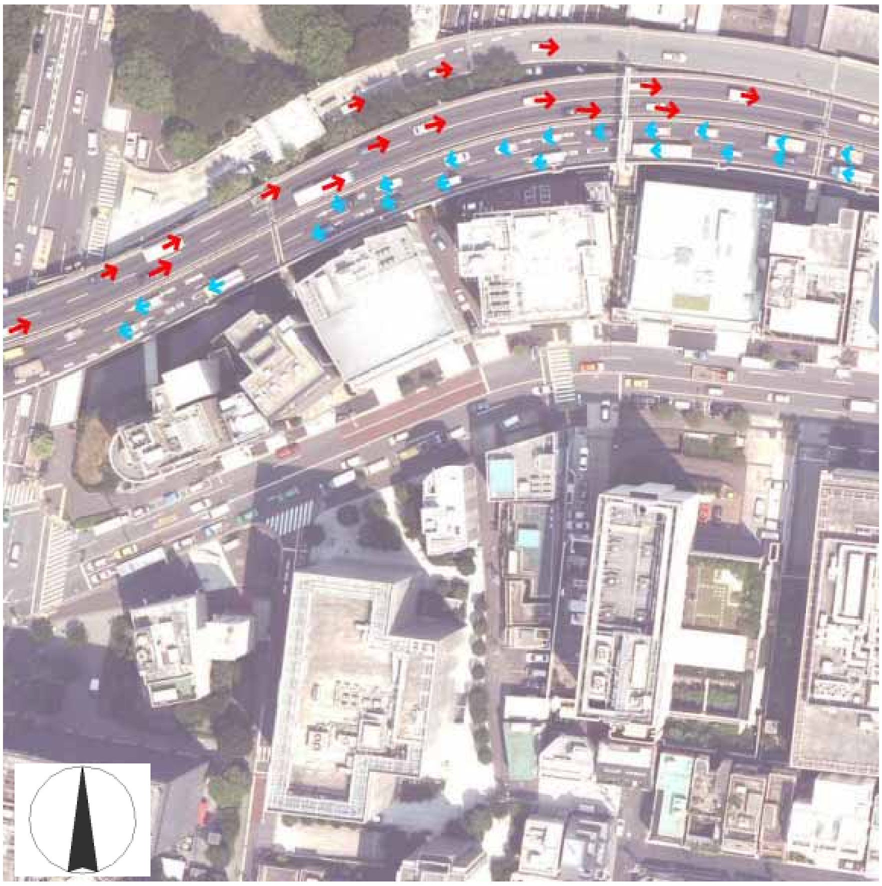
V_{ave} = 39.7 km/h

Lower Roadway



10km/h < v < 30km/h

V_{ave} =19.0 km/h



The length of the arrows ∝ the speed

The arrow directions mean the car directions

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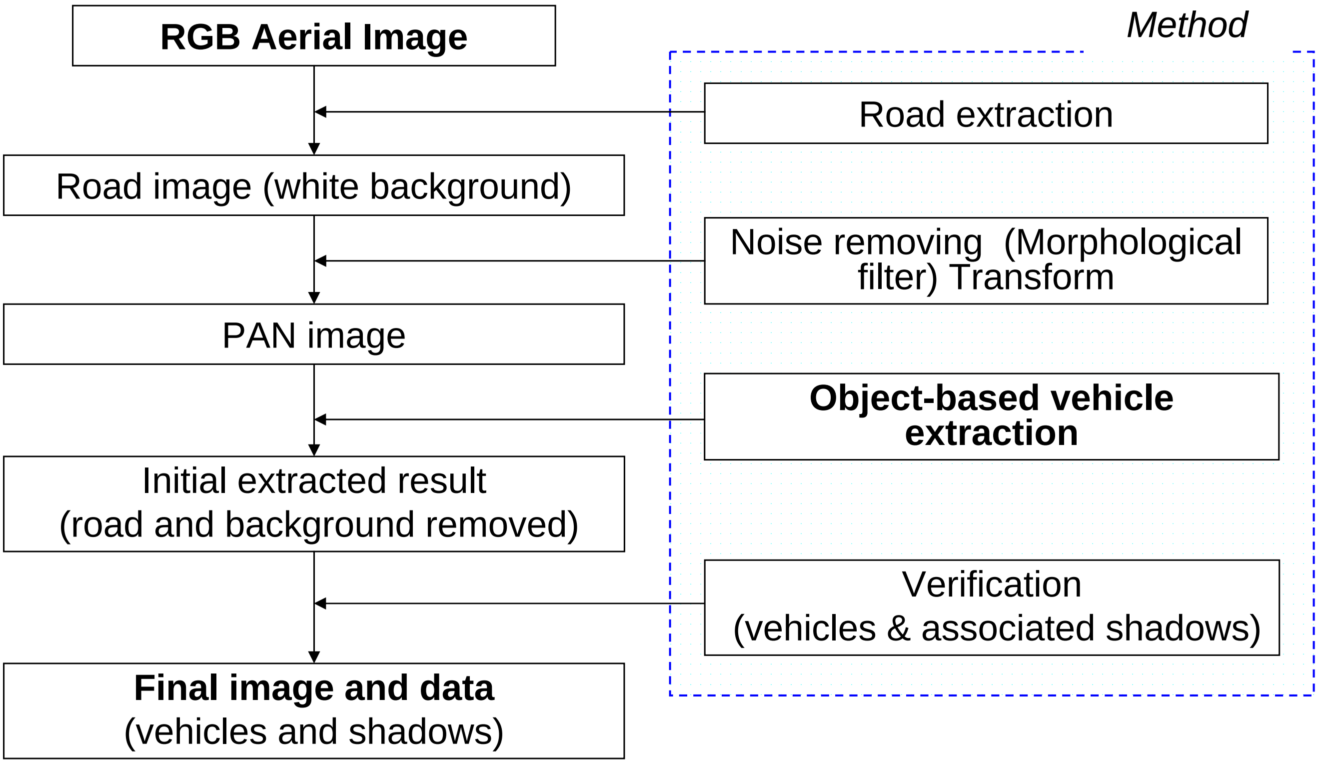
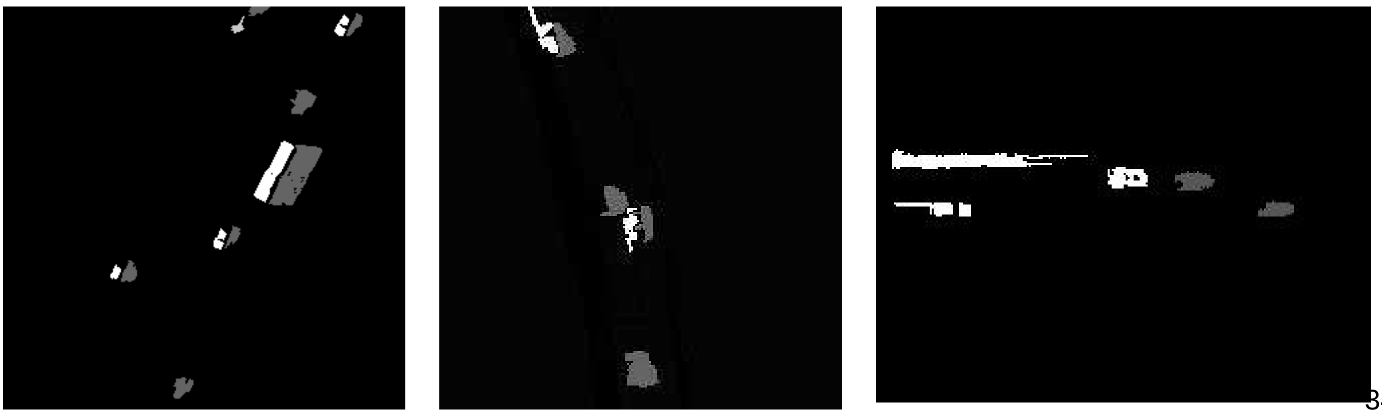
Flowchart of automated vehicle extraction



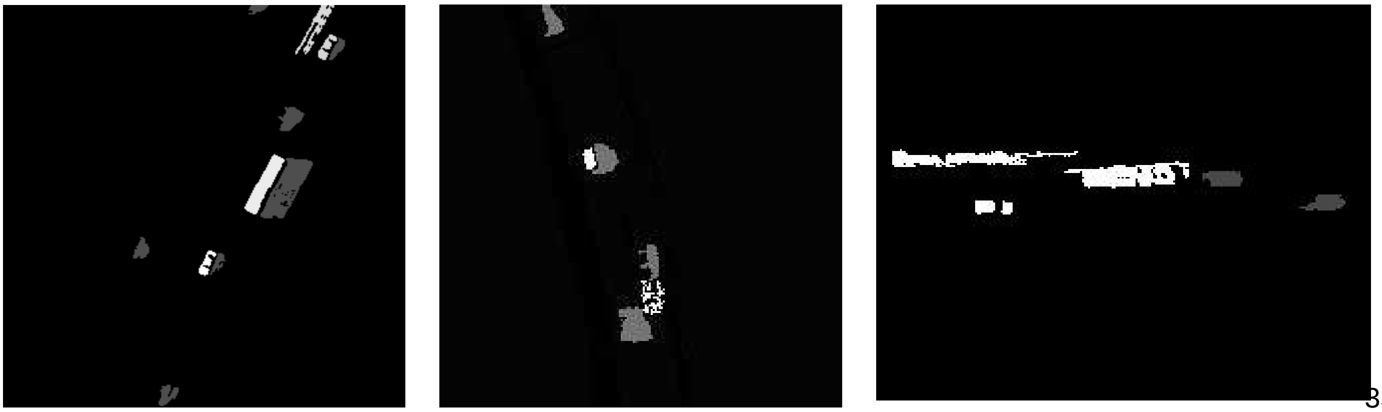
Before

vehicle extraction



After

vehicle extraction



Database (example)

before

Car ID	X/pixel	Y/pixel	Size/pixel
1	252	13	89
2	174	13	55
3	201	122	447
4	161	172	81
5	83	197	53
6	223	71	225
7	134	283	153
Shadow ID	**X/pixel**	**Y/pixel**	**Size/pixel**
1	261	13	94
2	190	3	73
3	217	125	827
4	170	171	87
5	93	196	126

after

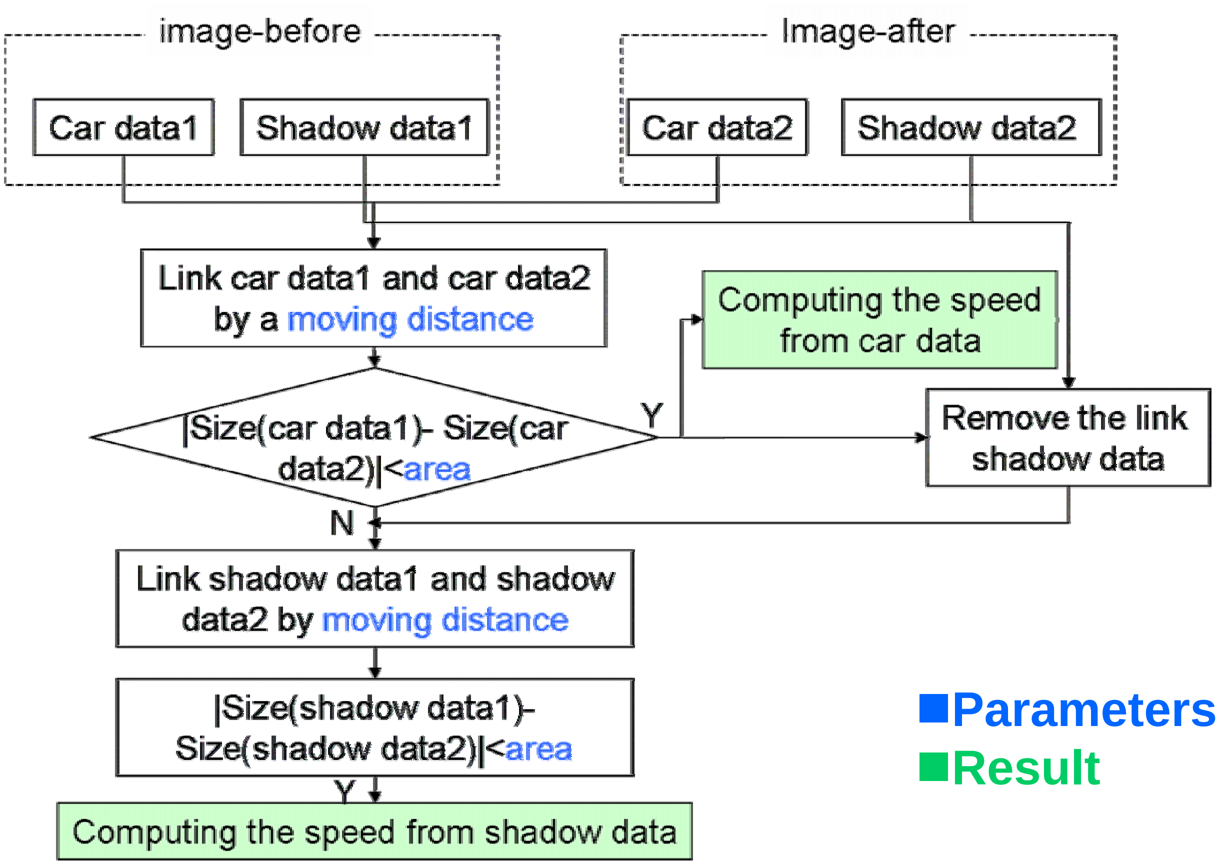
Car ID	X/pixel	Y/pixel	Size/pixel
1	232	18	245
2	241	31	108
3	194	133	453
4	152	192	100
5	190	3	65
6	214	84	214
7	102	180	121
8	123	290	139
Shadow ID	**X/pixel**	**Y/pixel**	**Size/pixel**
1	248	32	90
3	211	136	798
4	159	192	75

A shadow object has the same ID as a car's means it is cast by this car.

The last ID of shadow means the number of cars in the scene.

The number of cars is not the same, because of the noise.

Flowchart of speed detection



■Parameters
■Result

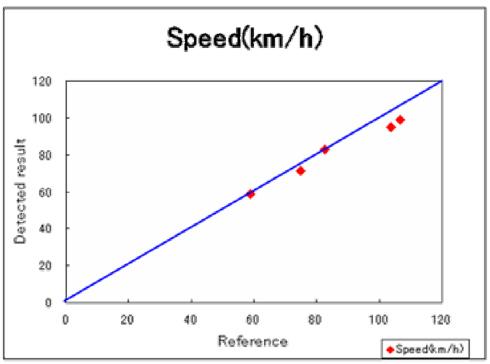
CarID	Distance(pixel)	Speed(km/h)	Direction(degree)
1	21.10	94.93	−121.43
2	0.00	0.00	0.00
3	13.04	58.67	−122.47
4	21.93	98.69	−114.23
5	18.36	82.61	60.64
6	15.81	71.15	−124.70
7	13.04	58.67	−147.53

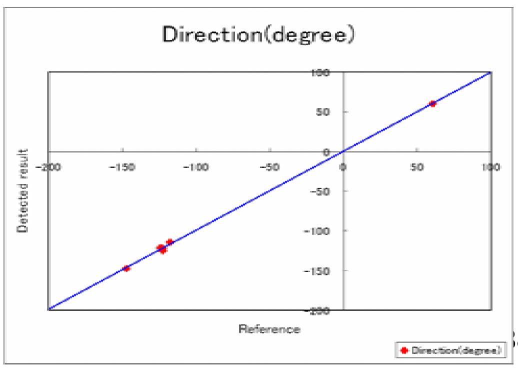
Result of speed detection

Reference data

	Distance (pixel)	Speed (km/h)	Direction (degree)
1	23.02	103.59	−124.4
2	13.04	58.68	−122.5
3	23.71	106.7	−117.6
4	18.36	82.62	60.6
5	16.64	74.88	−122.7
6	13.04	58.68	−147.5

The detected result shows good agreement with the reference data.





Summary

- The **time lag** between **Pan and MS bands of QB** images was highlighted to detect **moving objects**.
- The **speeds of vehicles** were visually detected from **QB images**, but accuracy was **not** very high.
- The **speeds of vehicles** were detected from **digital aerial images** with **high accuracy**.
- An **object-based automated** method of **vehicle extraction** from aerial images was **proposed**.