SAMSs detection agent with remote sensing images

Feng LIU, Jihong ZHU, Wufan WANG, Minchi KUANG

Background

Satellite photograph

Air-mapping

commonly used in :

Satellite & **Air-mapping** develop rapidly	quantity and quality of **remote sensing images** grow rapidly	Intelligence gathering Navigation Damage assessment Surveying and mapping

Background

Bottleneck : **Searching** for specific **military targets** from massive amounts of high resolution remote sensing images

- **Rely on manual judgement**
- **Searching range is small**
- **time-consuming and inefficient**

Missile launching trucks

fortifications

Military targets : surface to air missile sites (SAMSs)

SAMSs have a diameter of 100~200m
small target detection
Difficult to find in huge pictures.

Han J Y, Xing L X. The Recognition and Extraction of Surface to Air Missile Position Targets. Thesis, Jilin University, 2016.

Han reveals SAMSs are too small to find and he assumes that SAMSs are deployed to protect **airport** or **harbor**. So he tries to search airport then search SAMSs **nearby**

```
remote sensing images  --preprocess-->  mean filtering  --Decrease noise-->  Hough transformation
                                                                                      |
                                                                                straight line detection
                                                                                      v
SAMS  <--  feature extraction  <--  Airport detection
```

Limitation :

1, Although these traditional image processing algorithms are simple and efficient, they are incapable to process large-scale remote sensing images, especially small targets in complex background such as SAMSs.

2, The generalization abilities of artificial feature extraction is weak. Since there are remarkable differences on SAMSs in different countries. Artificial feature extraction is already too cumbersome.

3, Han's method aims at the SAMSs nearby airport or harbor, could not find those hide in mountain areas or other places.

Solution :

1, Propose a detection framework based on **deep learning approaches**.

2, Conduct a **SAMSs dataset** of different countries.

3, Select a **sliding window** when searching SAMSs so as to search each area.
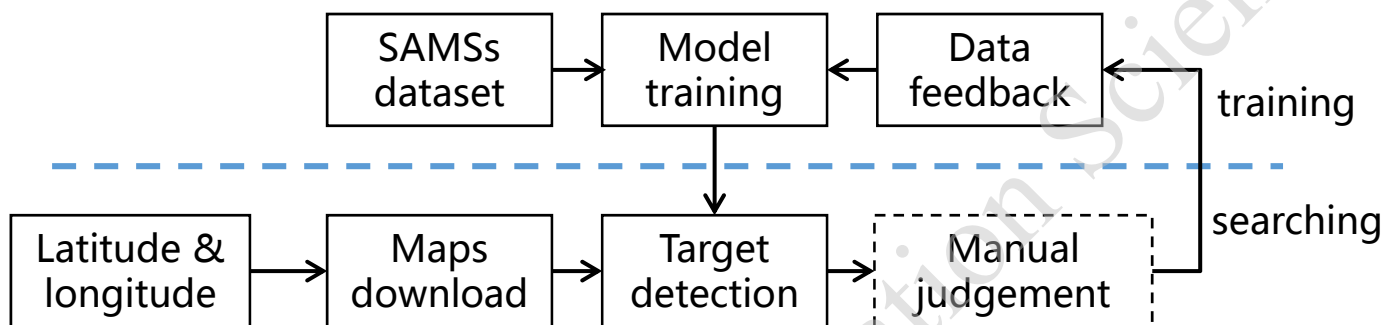
Training :
we conduct a SAMSs dataset of different countries and compare two typical methods' performance, you only look once v3 (YOLO-v3) and Faster RCNN.
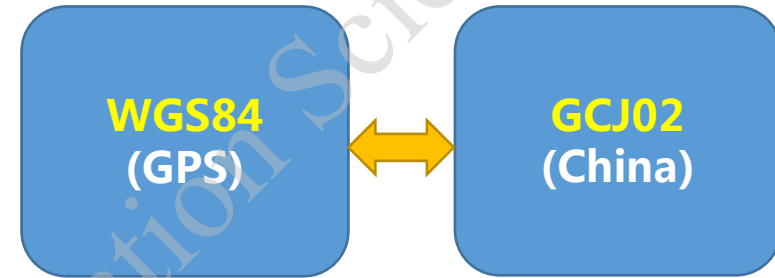
Searching :
we **download** all the maps based on **latitude and longitude**. The trained model takes the **SAMSs dataset** as input. After judging the detection results, some confirmed and suspected SAMSs are indicated on the map. At last, these confirmed results will be **returned** to the dataset to optimize the model.

Difficulty
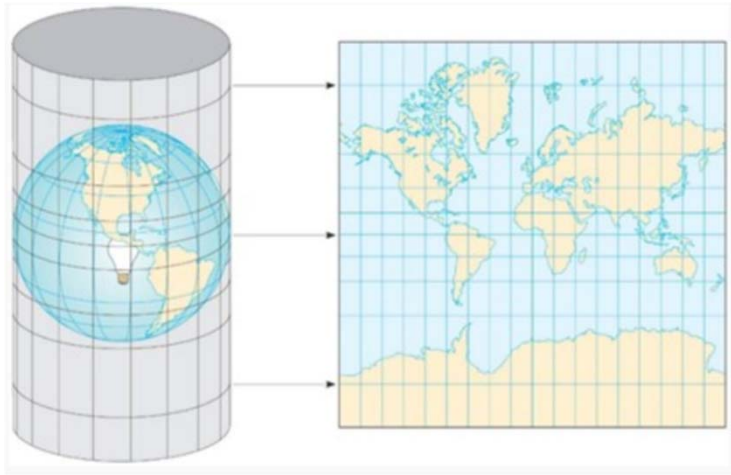
Mercator projection

transformation of coordinate systems

WGS84 (GPS) ⟷ GCJ02 (China)

interpolation between different resolutions

Dataset
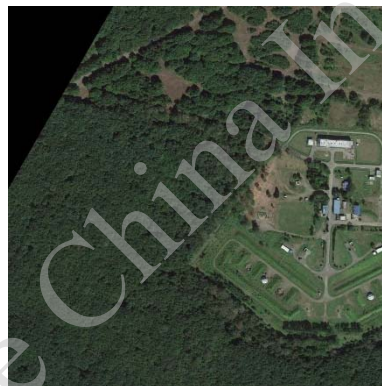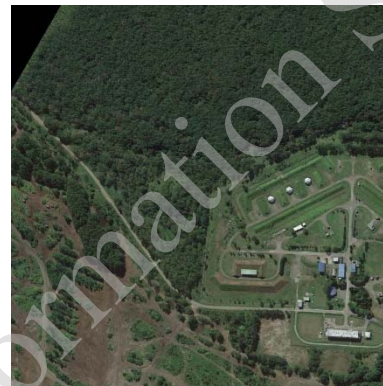
SAMSs Dataset

Patriot

Hawk
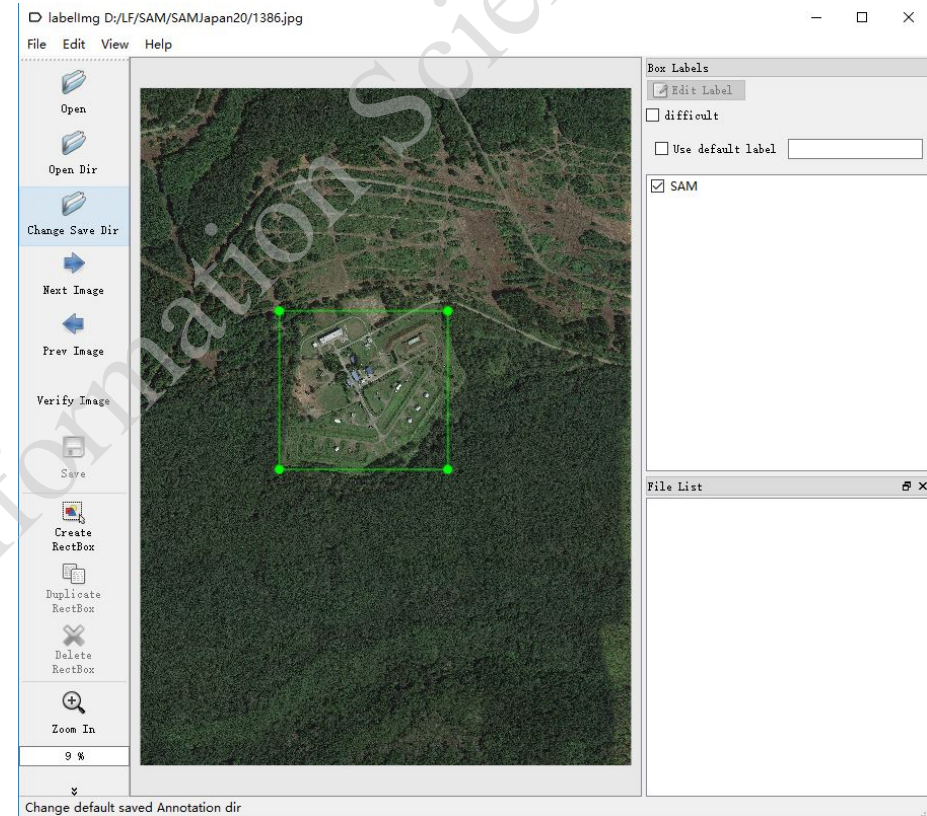
High resolution :
The ground sample distance (GSD) is from 0.15m to 0.6m

We collect 1,332 SAMSs images from **Google Map** and annotate them with **LabelImg**

Data augmentation

The shooting angle of remote sensing images is from top to bottom, resulting that each target could face in all directions.

translation   rotation   flipping

The size of the dataset has increased to 10443.

Model training

YOLO-v3 and faster RCNN take the dataset as input.
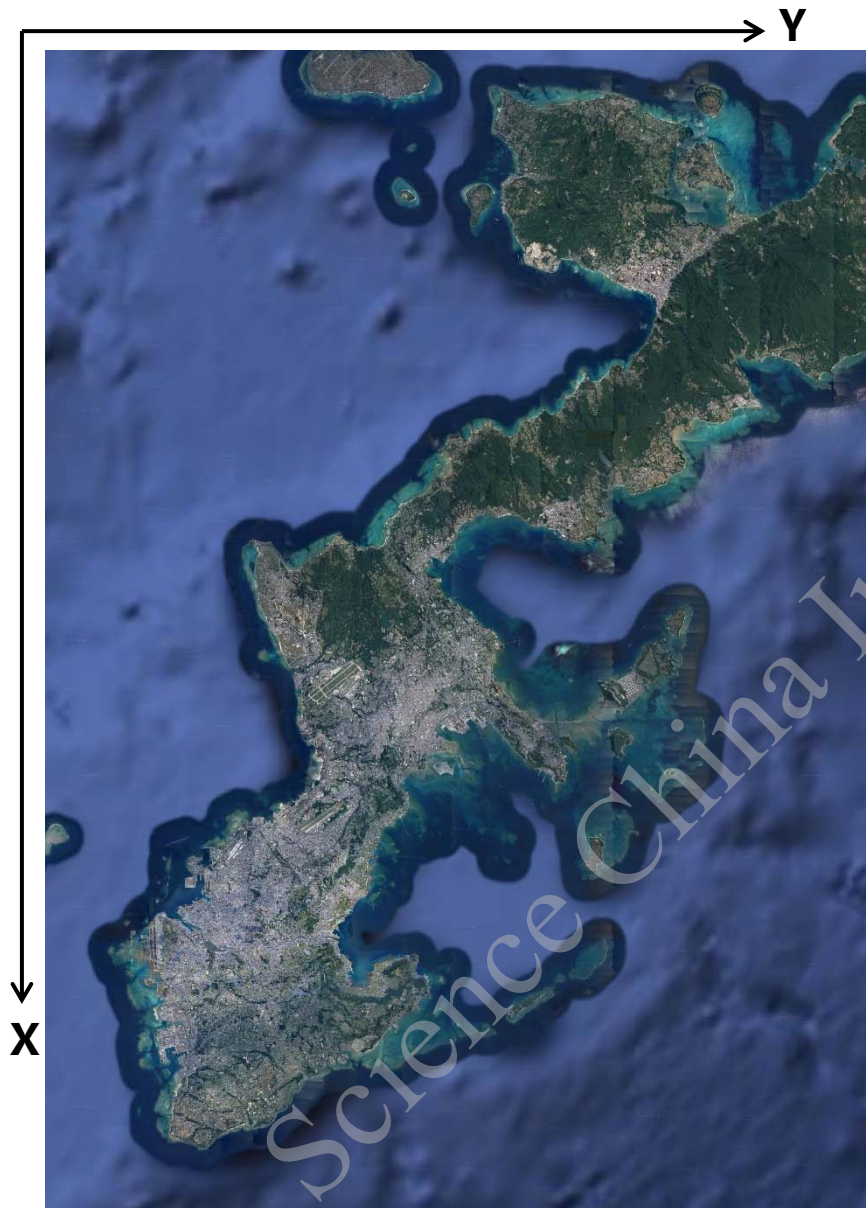For Faster RCNN, we adopt pre-trained VGG16 and Resnet101 models to extract feature respectively.

Detection results

Model		Precision (%)	Rate (fps)
YOLO-v3		32.05	27
Faster RCNN	VGG16	85.9	4
	VGG16-DA	87.18	4
	Resnet101	82.05	4
	Resnet101-DA	91.02	4

"DA" means Data augmentation

Although YOLO-v3 is six times faster than Faster RCNN, in remote sensing images for detection task, we prefer **higher accuracy**.
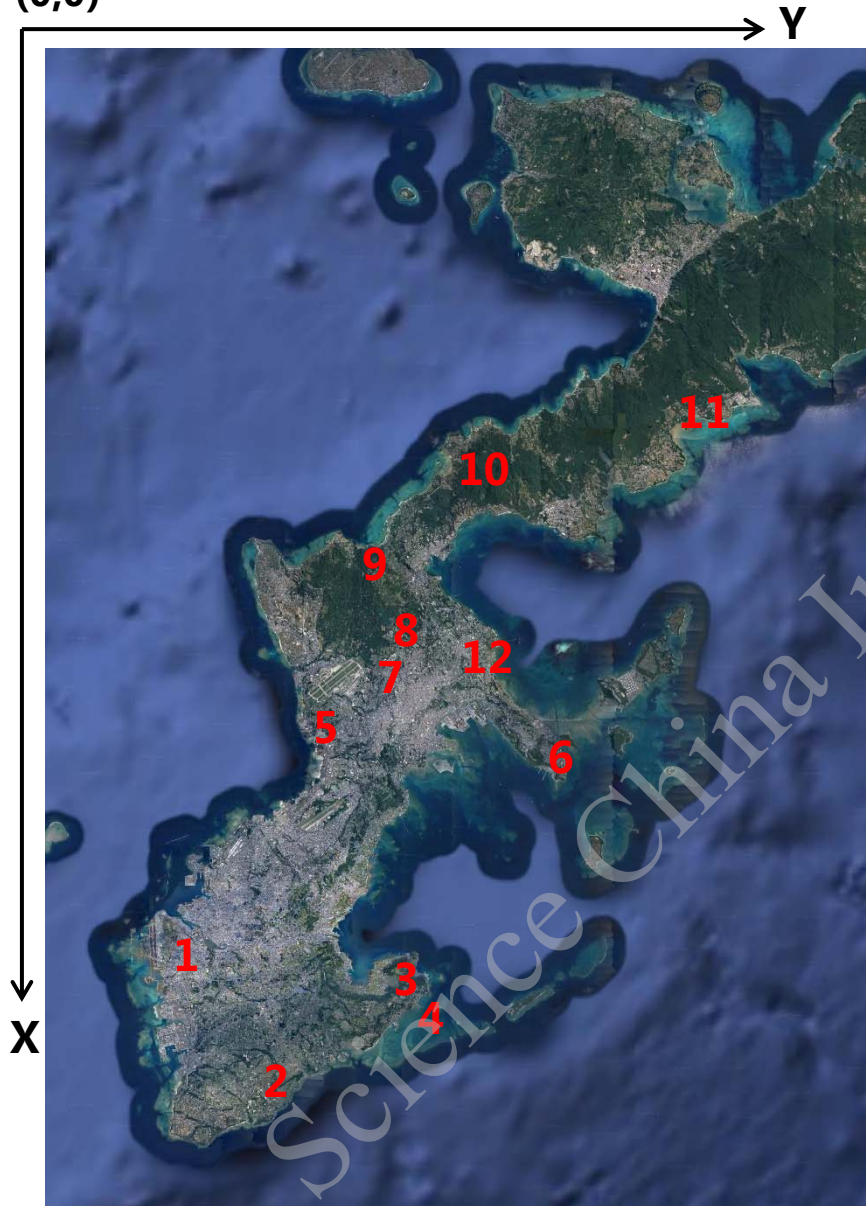In addition, **data augmentation** increases training time but reduces errors observably.

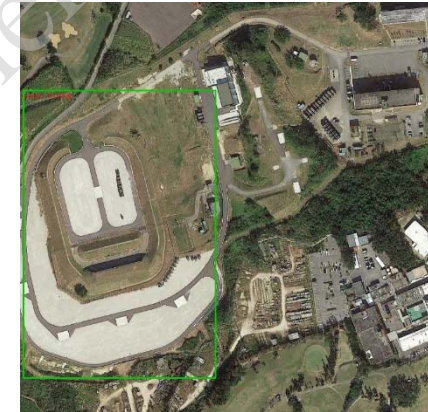We search this area about $6,000\ km^2$ consists of more than 40,000 remote sensing images.

Latitude & longitude → Tile coordinates

Skip the ocean → Maps download

Model :
Faster RCNN
with Resnet101 &
data augmentation → Target detection

Manual judgement

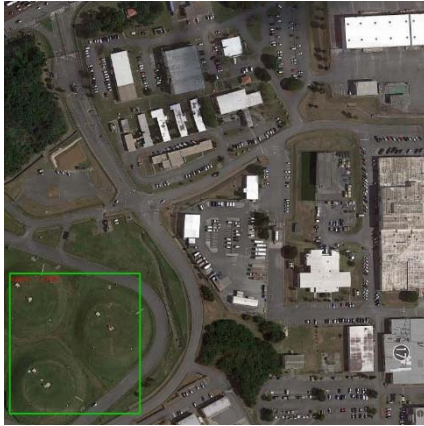Results show
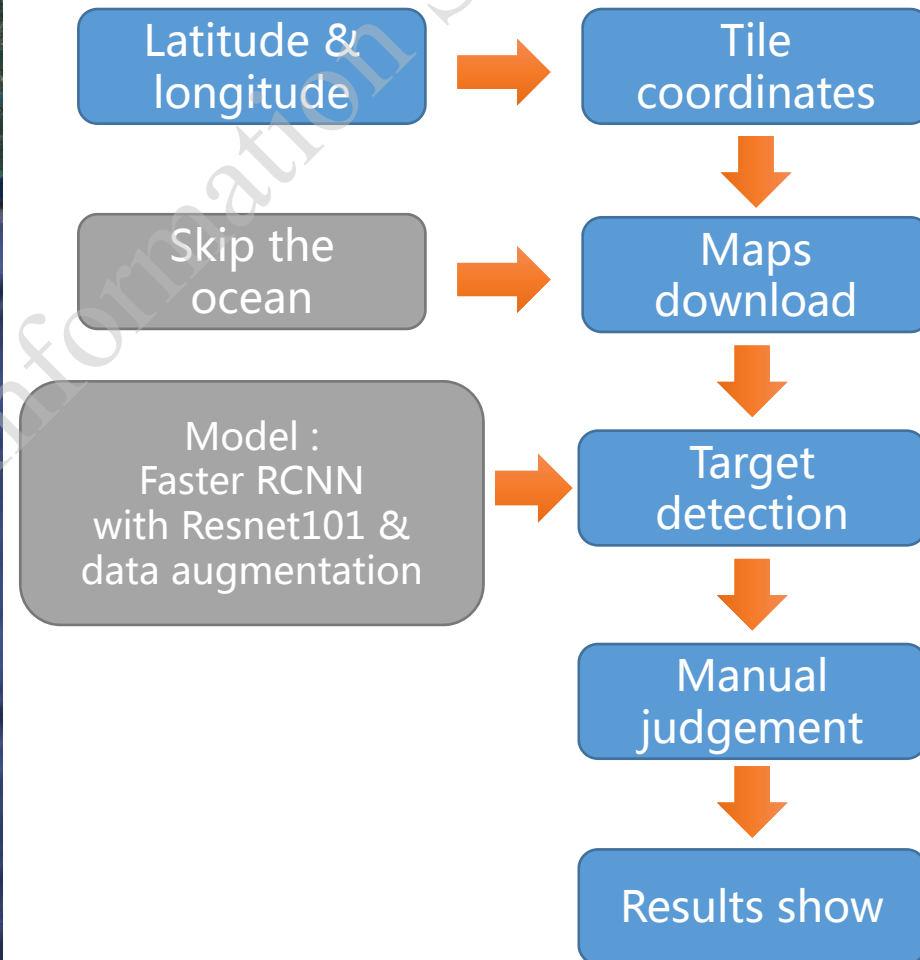
No.1 confirmed Patriot
(183,10)

No.2 confirmed Hawk
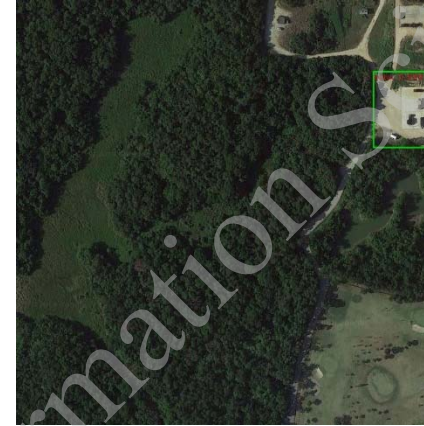(204,27)

No.3 confirmed Patriot
(190,51)

No.4 confirmed Hawk
(191,52)

No.5 confirmed Patriot
(139,36)

No.6 confirmed Hawk
(152,73)

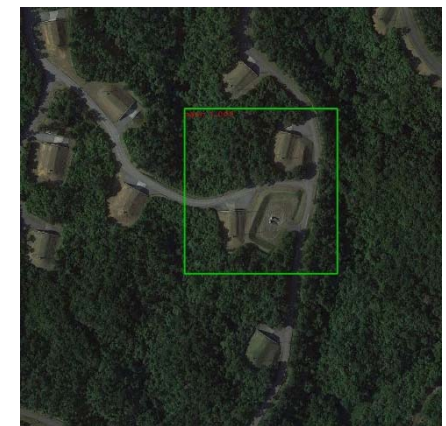No.7 confirmed Patriot
(135,46)

No.8 confirmed Patriot
(131,48)

No.9 confirmed Patriot
(135,46)

No.10 confirmed Hawk
(122,45)

No.11 suspected
new position
(91,107)

No.12 suspected
new position
(130,46)

Due to the particularity of military installations, every country's SAMSs are infrequent in dataset. Once some new SAMSs are confirmed, these images will be added to dataset to increase **positive samples**.

Furthermore, **negative samples** (false positive, containing similar buildings, farmland and parking lots) feedback could reduce the false alarm probability.
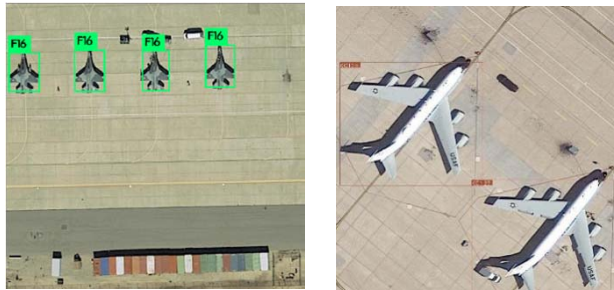

positive samples : Hawk & Patriot

negative samples :
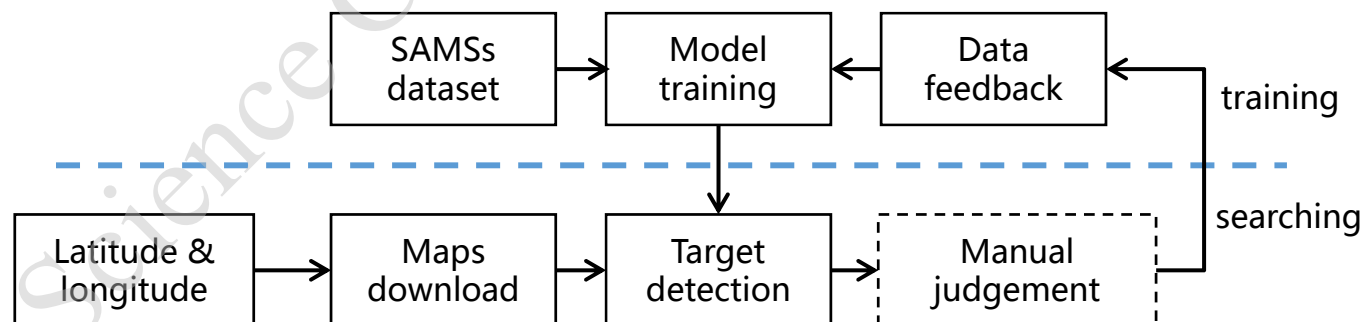driving school & farmland

Fighter aircraft dataset

Airport dataset

SAMSs dataset

Early warning radar dataset

| SAMSs dataset | → | Model training | ← | Data feedback | ← | training |

| Latitude & longitude | → | Maps download | → | Target detection | → | Manual judgement | searching |

Thank you