UNIUNEA EUROPEANĂ

Instrumente Structurale
2014-2020

GPU based machine learning techniques for classifying objects in astronomical images using CloudUT

UNIVERSITATEA TEHNICĂ
DIN CLUJ-NAPOCA

CloudUT

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CloudUT Project

Titlu: Cloud Cercetare UTCN – CLOUDUT

(http://cloudut.utcluj.ro)

MySMIS ID: 124493

Contract nr: 235/ 21.04.2020

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Tip Proiect: Program Operațional Competitivitate 2014-2020 (POC)

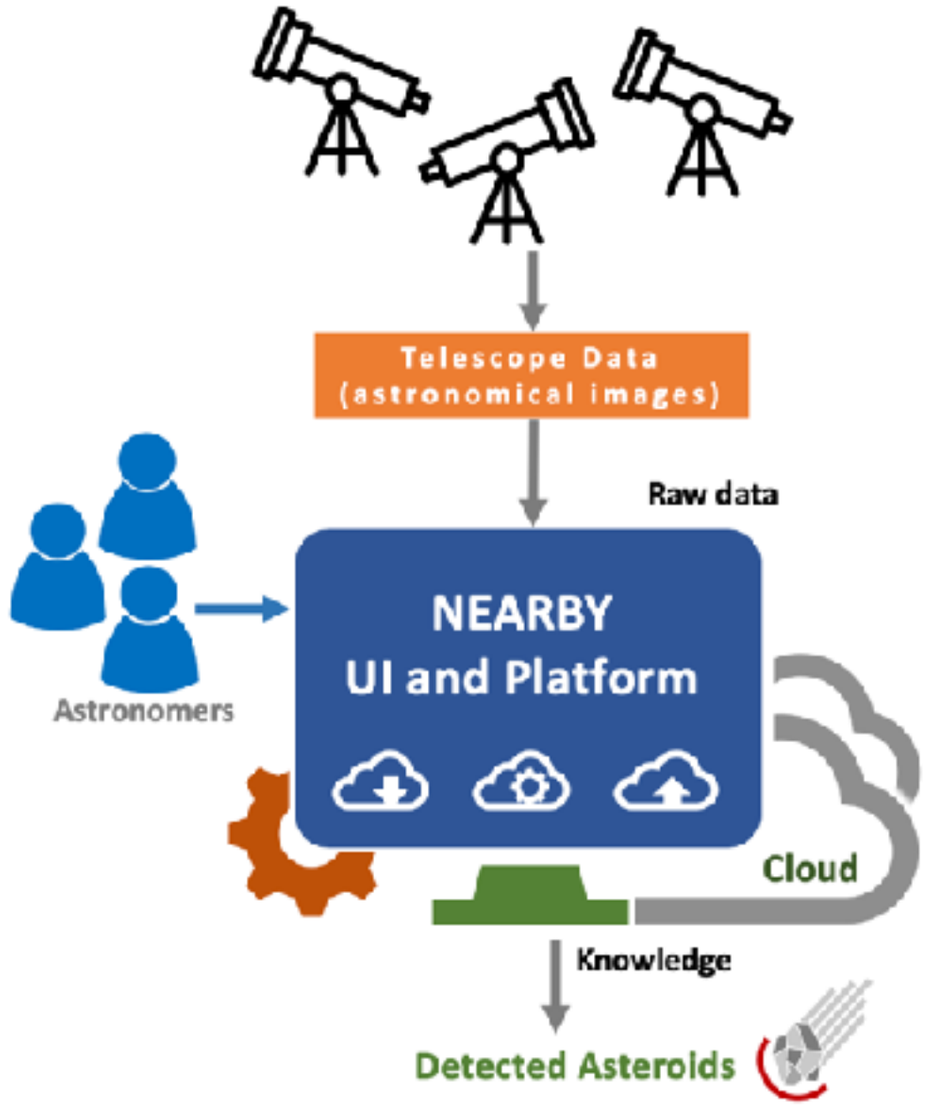
Axa prioritara 1: Cercetare, dezvoltare tehnologică și inovare (CDI) în sprijinul competitivității economice și dezvoltării afacerilor

Acțiunea 1.1.2: Dezvoltarea unor rețele de centre CD, coordonate la nivel național și racordate la rețele europene și internaționale de profil și asigurarea accesului cercetătorilor la publicații științifice și baze de date europene și internaționale

Finanțare: Fonduri Europene pentru Dezvoltare Regională, Valoarea totală: 4.955.000 RON, din care 4.950.000 RON din fonduri Europene.

NEARBY@CloudUT Objectives

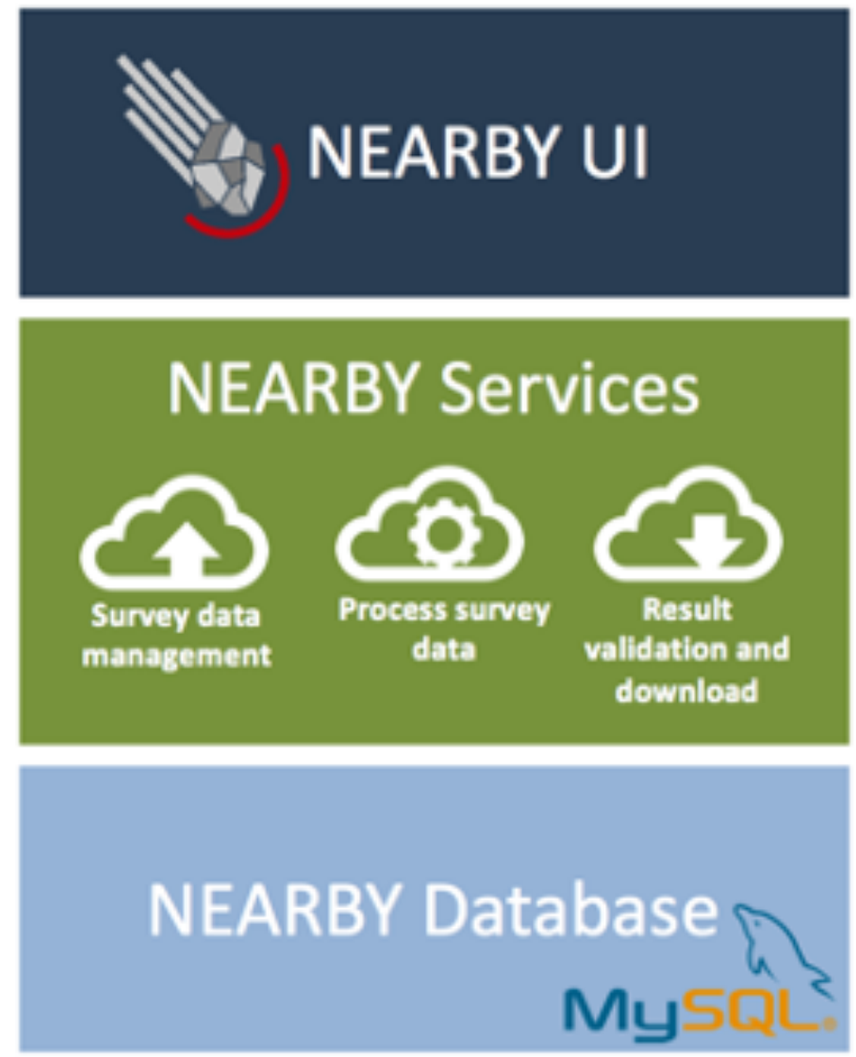
- Processing and analysis of astronomical images
- Visual analysis and human validation
- Cloud based processing



Stakeholders

- Astronomers
- Software developers
- UTCN teams
- Projects (ex. CERES)
- Others

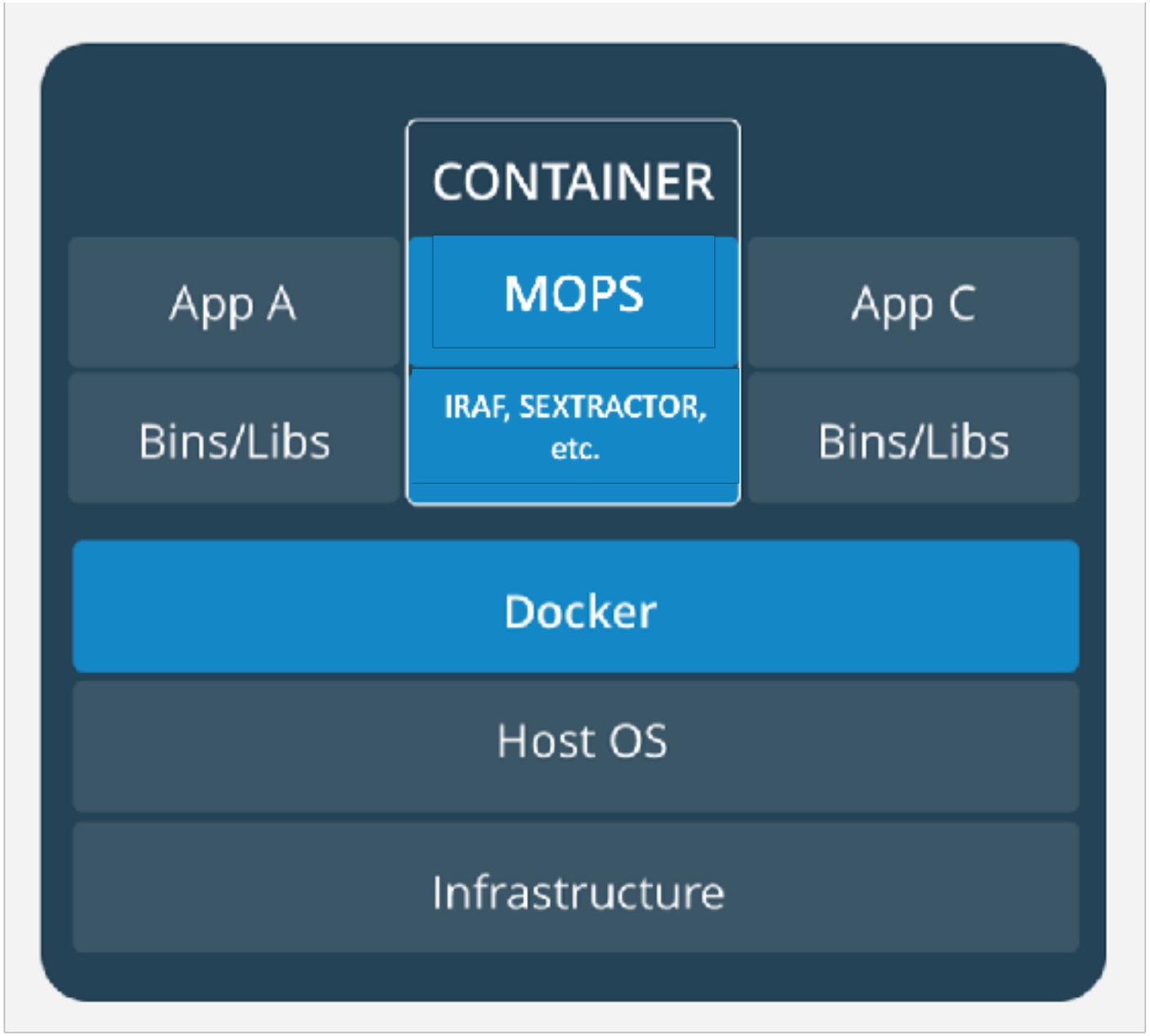
Architecture



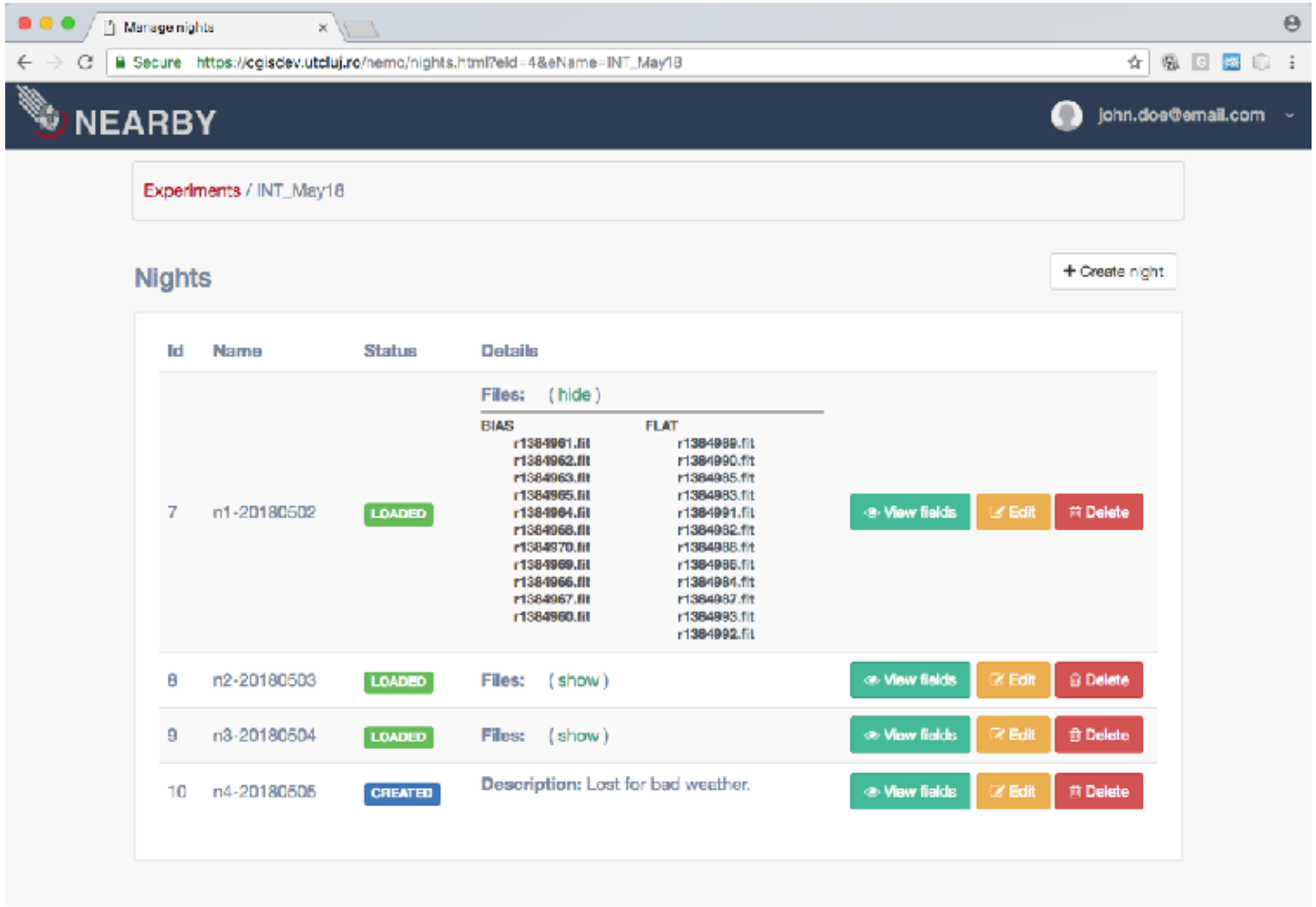
Technical requirements

- Deploy: Docker, Kubernetes, Rancher
- Software packages (installed in Docker images): Astropy, Sextractor, Scamp, Swarp, etc.
- Developement language: Python
- Hardware resources: CPU (6 core-uri), RAM (64 GB), HDD (500 GB)

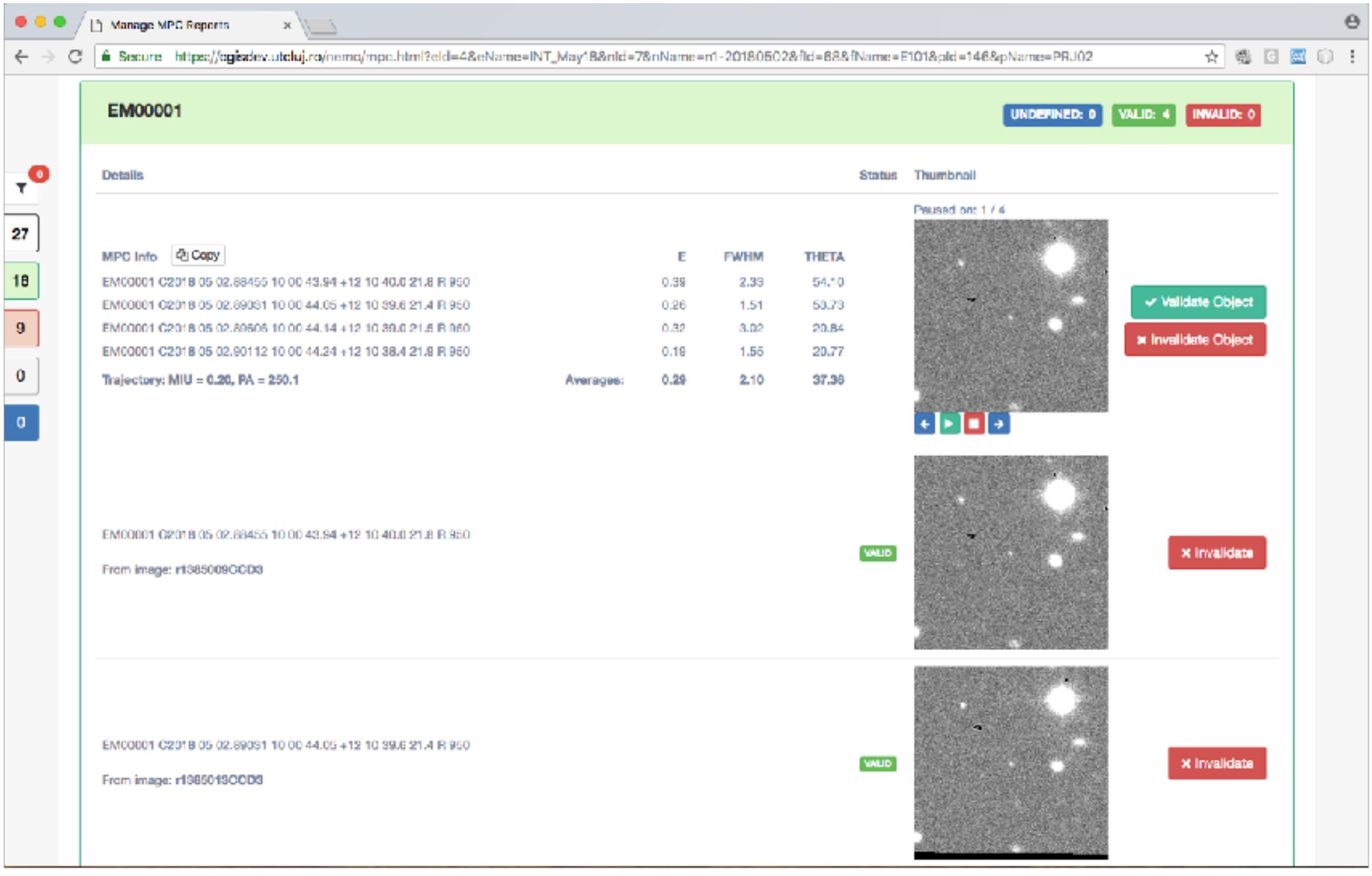
Docker container



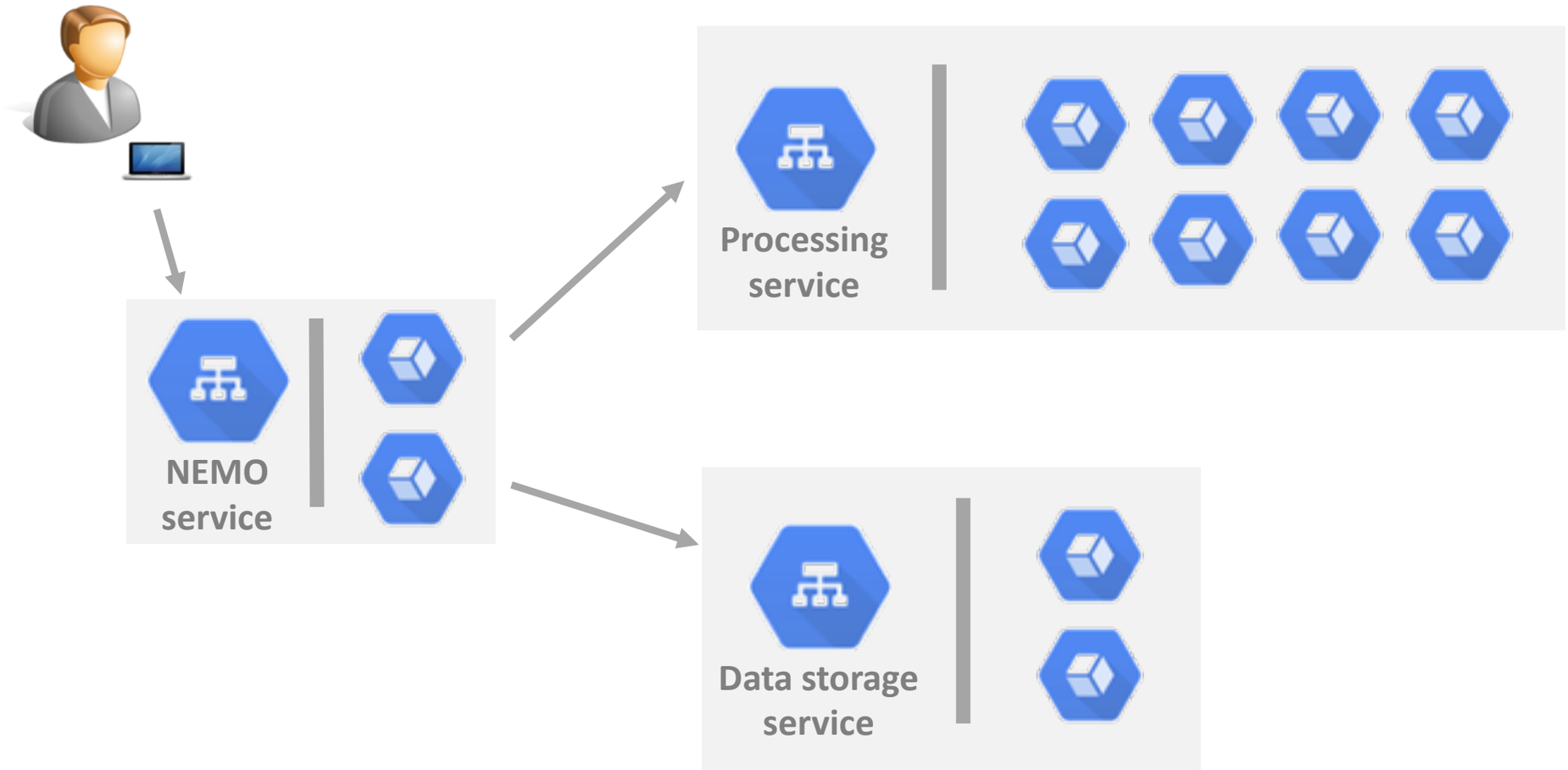
NEARBY@CloudUT UI



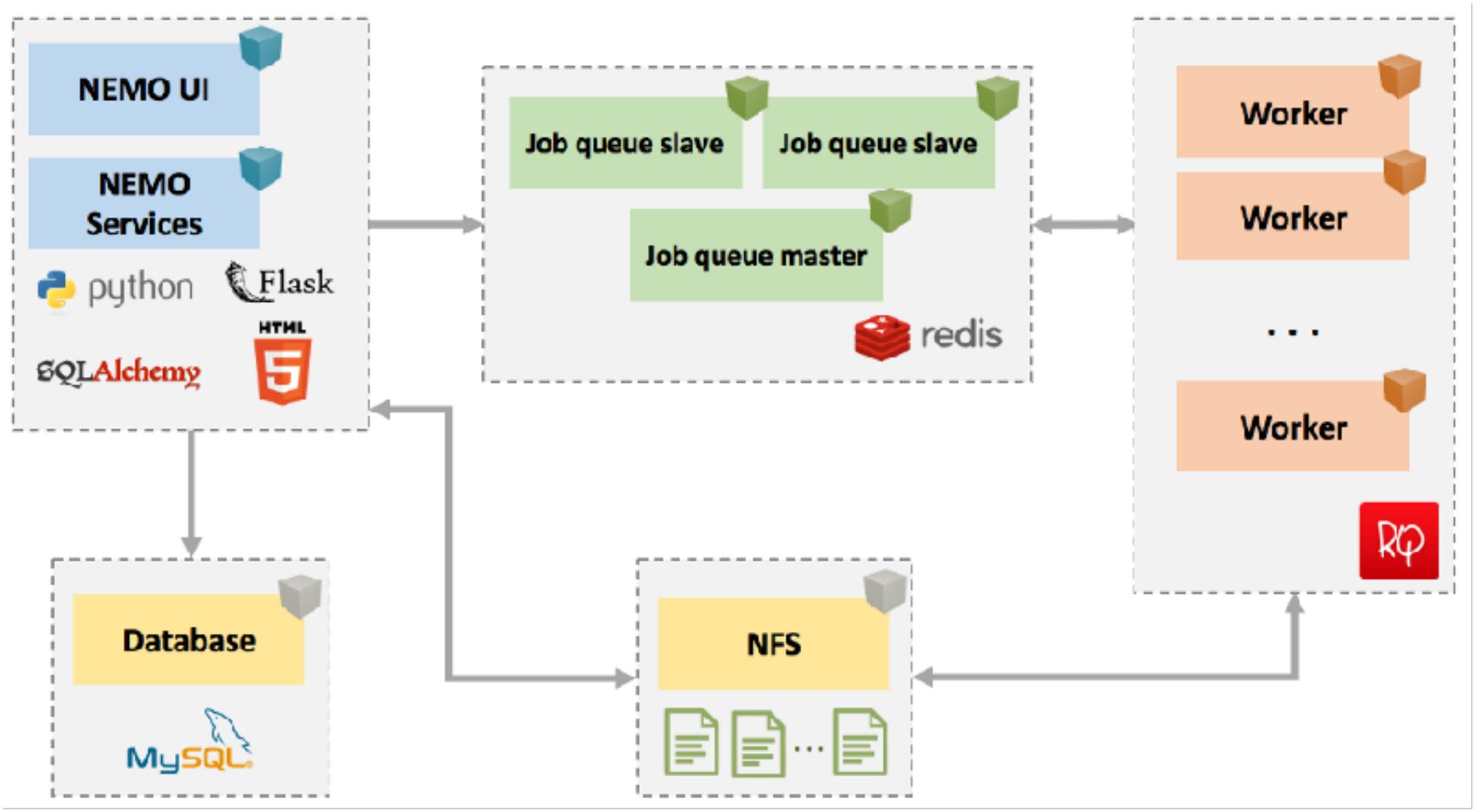
NEARBY@CloudUT UI



Services



Services


NEMO UI
NEMO Services
python
Flask
HTML
SQLAlchemy
Job queue slave
Job queue slave
Job queue master
redis
Worker
Worker
...
Worker
RQ
Database
MySQL
NFS

CERES Project

Proiect: 403PED / 2020

Denumirea Programului din PN III:

Programul 2 - Creșterea competitivității economiei românești prin cercetare, dezvoltare și inovare

Denumirea Subprogramului:

Subprogramul 2.1 - Competitivitate prin cercetare, dezvoltare și inovare

Tip proiect:

Proiect experimental - demonstrativ

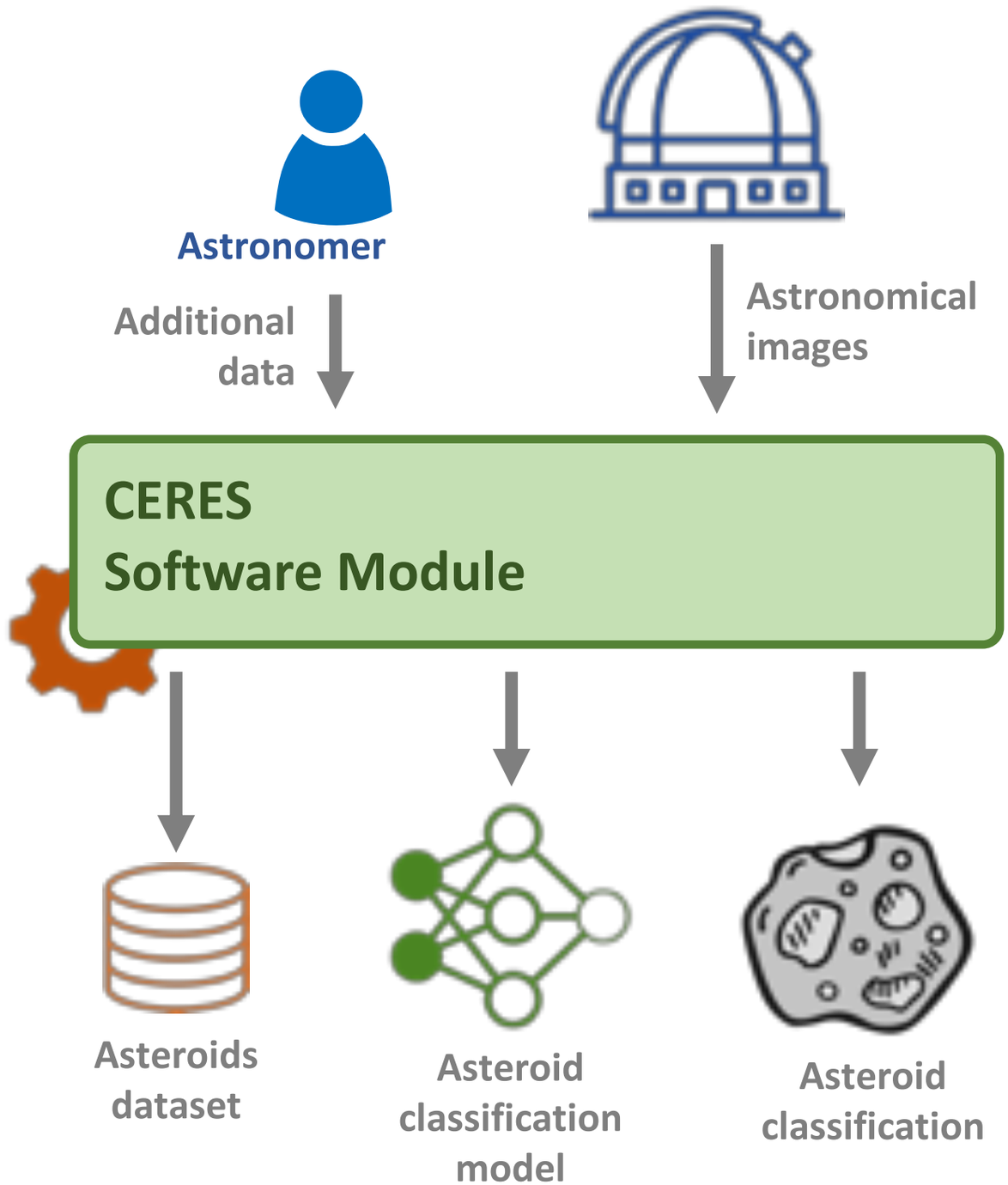
Autoritatea Contractantă:

Unitatea Executivă pentru Finanțarea Învățământului Superior, a Cercetării, Dezvoltării și Inovării

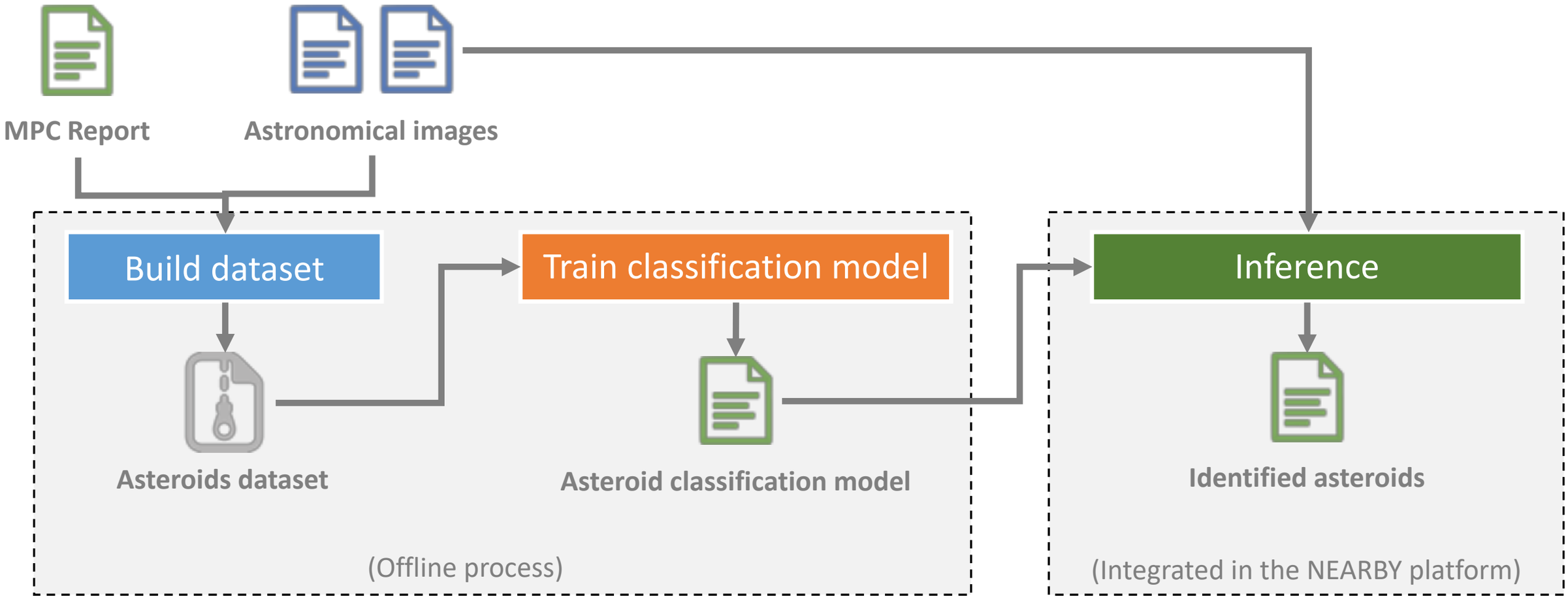
Objectives

- Building up a dataset of asteroid images
- Training an asteroid detection classification model
- Developing a software module used to classify detections (of asteroids)

CERES outcome



CERES module

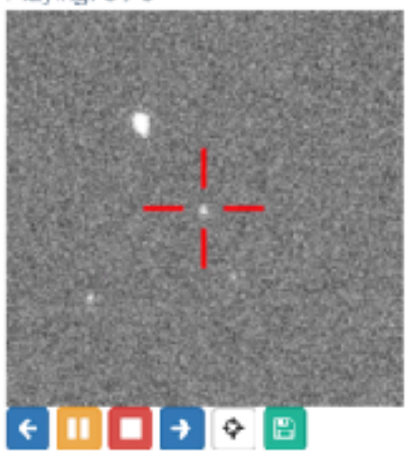


Valid detection

EM00006

UNDEFINED: 0 | VALID: 5 | INVALID: 0

Details					Status	Thumbnail
MPC Info (Copy)		E	FWHM	THETA		Playing: 3 / 5
EM00006 C2018 09 17.19156 03 16 12.21 +26 19 57.3 21.4 R 950		0.39	1.53	88.18		
EM00006 C2018 09 17.19997 03 16 12.16 +26 20 00.1 21.1 R 950		0.25	1.53	-80.74		
EM00006 C2018 09 17.20829 03 16 12.12 +26 20 03.0 21.1 R 950		0.28	1.51	85.11		
EM00006 C2018 09 17.21667 03 16 12.10 +26 20 05.7 20.6 R 950		0.37	1.89	-87.05		
EM00006 C2018 09 17.22511 03 16 12.06 +26 20 08.6 21.0 R 950		0.27	1.43	83.84		
Trajectory: MIU = 0.24, PA = 10.1	Averages:	0.31	1.58	13.87		



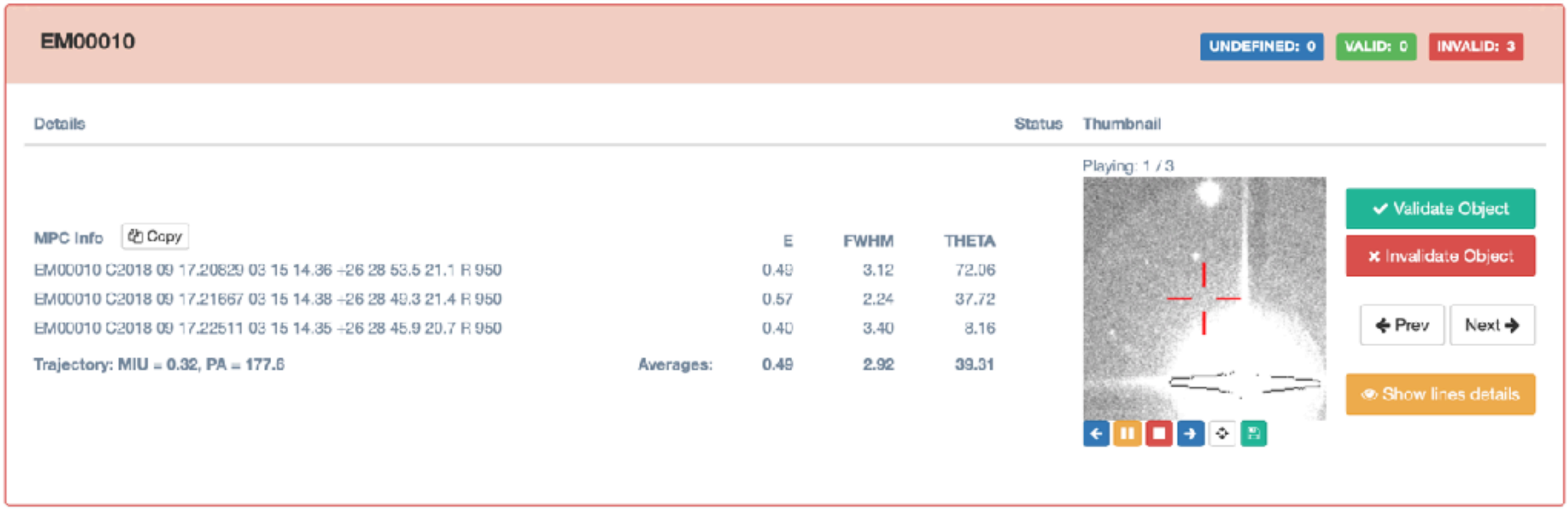
✔ Validate Object

✖ Invalidate Object

← Prev | Next →

Show lines details

Invalid detection



Dataset

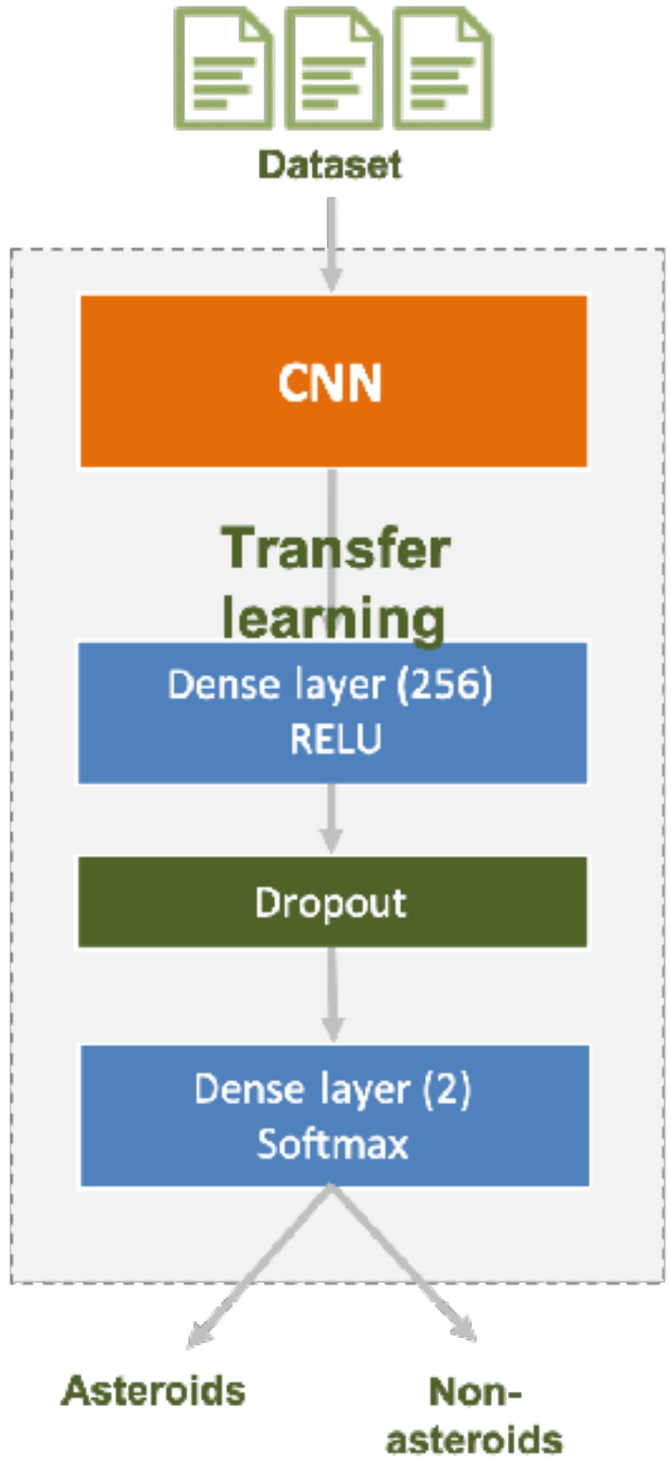
- **Input**
  - Preprocessed astronomical images (NEARBY)
  - MPC files containing detections validated by astronomers
  - SkyBot
- **Output - fits images (200 x 200 px)**
  - Valid detections (asteroids)
  - Valid detections by SkyBot but invalidated by astronomers
  - Valid detections by astronomers by invalidated by SkyBot
  - Invalid detections (asteroids)

Dataset

	Valid images	Invalid images
INT_Feb2020	694	1643
INT_Jan2020	4150	9566
INT_Oct2019	2307	4957
INT_Oct2020_run1	433	747
INT_Oct2020_run2	2331	5983
INT_Sep2020	1587	3034
INT_Nov2018	6266	8037
INT_Dec2018	6729	10909
Total	**24497**	**44876**

Convolutional neural networks

- InceptionResNetV2
- InceptionV3
- Xception
- ResNet152V2



Evaluation metrices

$$Accuracy = \frac{TP+TN}{TP+FP+TN+FN}$$

$$Precision = \frac{TP}{TP+FP}$$

$$Recall = \frac{TP}{TP+FN}$$

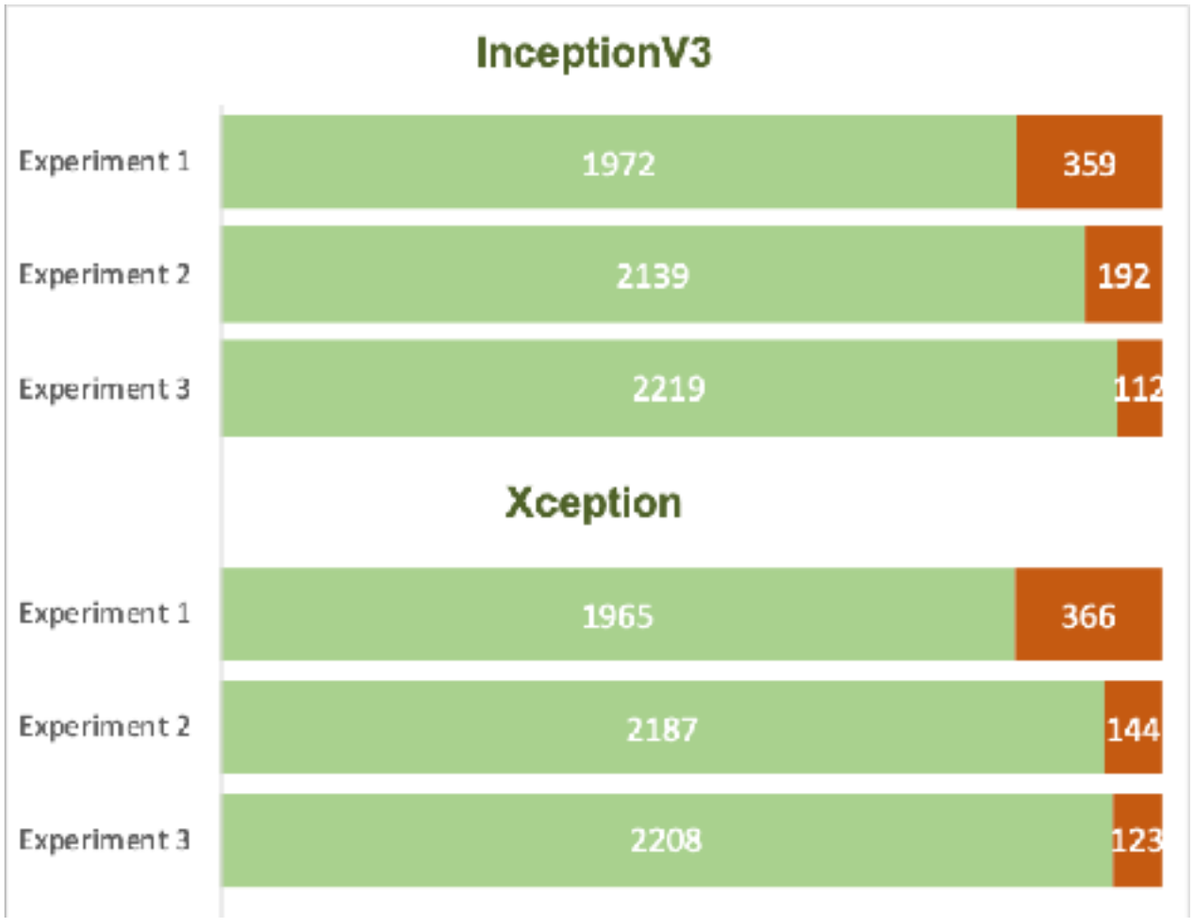
Dataset

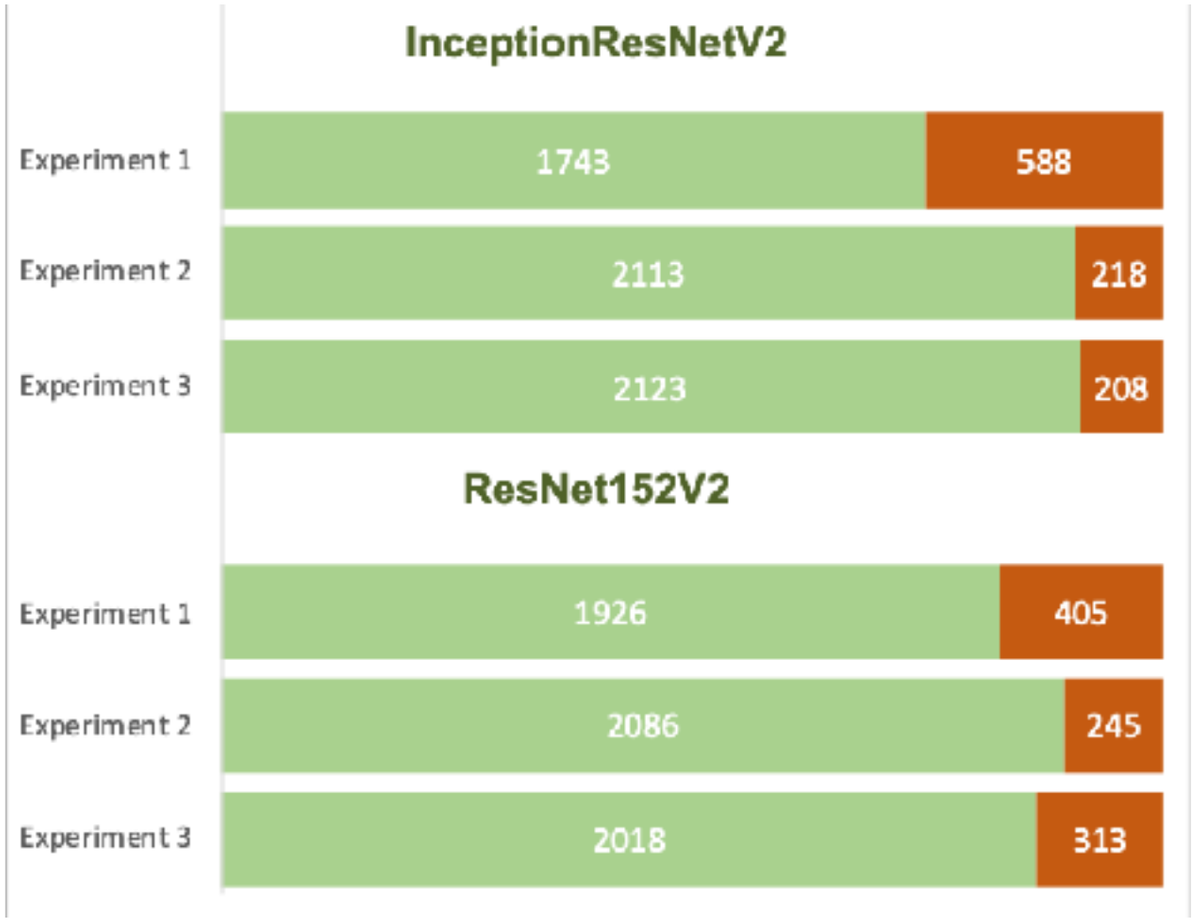
	Non-asteroid class	Asteroid class
Training set	38146	21733
Validation set	433	747
Test set	5983	2331

Results

		InceptionV3		
		precision	recall	f1-score
Experiment 1	Non-asteroid class	0.94	0.88	0.91
	Asteroid class	0.73	0.85	0.79
Experiment 2	Non-asteroid class	0.97	0.92	0.94
	Asteroid class	0.82	0.92	0.86
Experiment 3	Non-asteroid class	0.98	0.91	0.94
	Asteroid class	0.81	0.95	0.87

Results


InceptionV3
Experiment 1
1972
359
Experiment 2
2139
192
Experiment 3
2219
112
Xception
Experiment 1
1965
366
Experiment 2
2187
144
Experiment 3
2208
123


InceptionResNetV2
Experiment 1
1743
588
Experiment 2
2113
218
Experiment 3
2123
208
ResNet152V2
Experiment 1
1926
405
Experiment 2
2086
245
Experiment 3
2018
313

Performance comparison

CloudUT GPU (NVIDIA V100) - 1 epoch

xception - 75s

inceptionV3 - 70s

inceptionresnetv2 - 95s

CGIS GPU (NVIDIA Tesla K20) - 1 epoch

xception - 100s

inceptionV3 - 95s

inceptionresnetv2 - 125s

Conclusions

- Processing and analysis of astronomical images
- Visual analysis and human validation
- Cloud based processing
- Building up a dataset of asteroid images
- Training an asteroid detection classification model

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Thanks! Questions?

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