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Instrumente Structurale
2014-2020

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



UNIVERSITATEA TEHNICĂ
DIN CLUJ-NAPOCA



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CloudUT Project

Titlu: Cloud Cercetare UTCN – CLOUDUT

(<http://cloudut.utcluj.ro>)

MySMIS ID: 124493

Contract nr: 235/ 21.04.2020

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

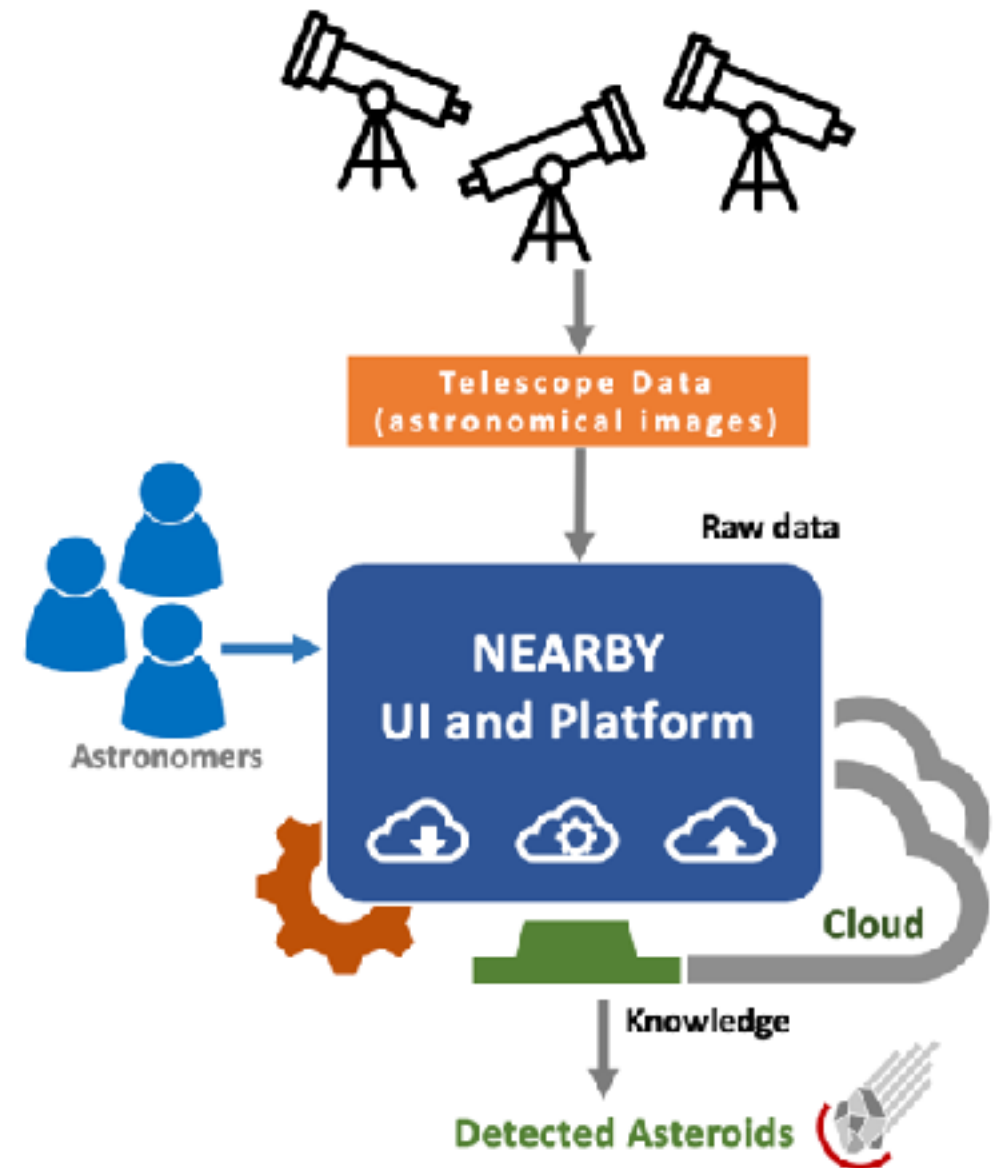
Finanțare: Fonduri Europene pentru Dezvoltare Regională, Valoarea totală: 4.955.000 RON, din care 4.950.000 RON din fonduri Europene.



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NEARBY@CloudUT Objectives

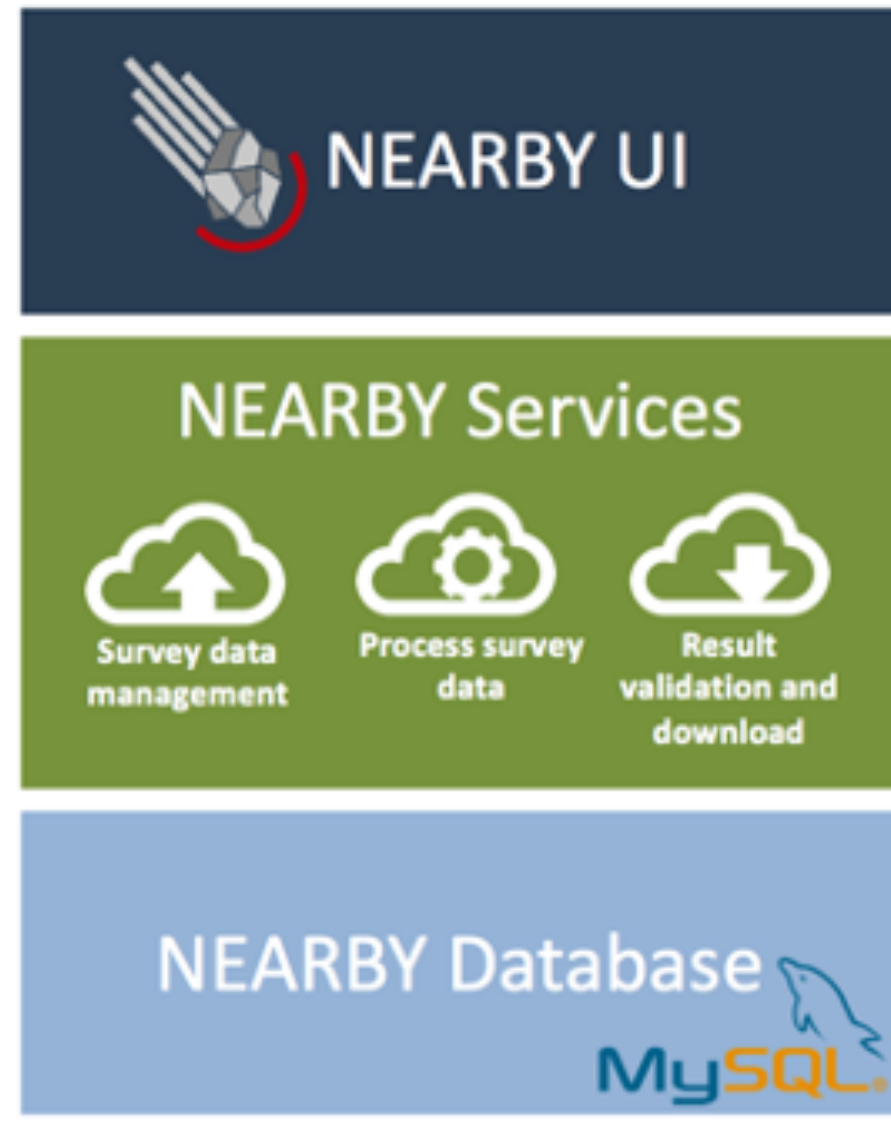
- Processing and analysis of astronomical images
- Visual analysis and human validation
- Cloud based processing



Stakeholders

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

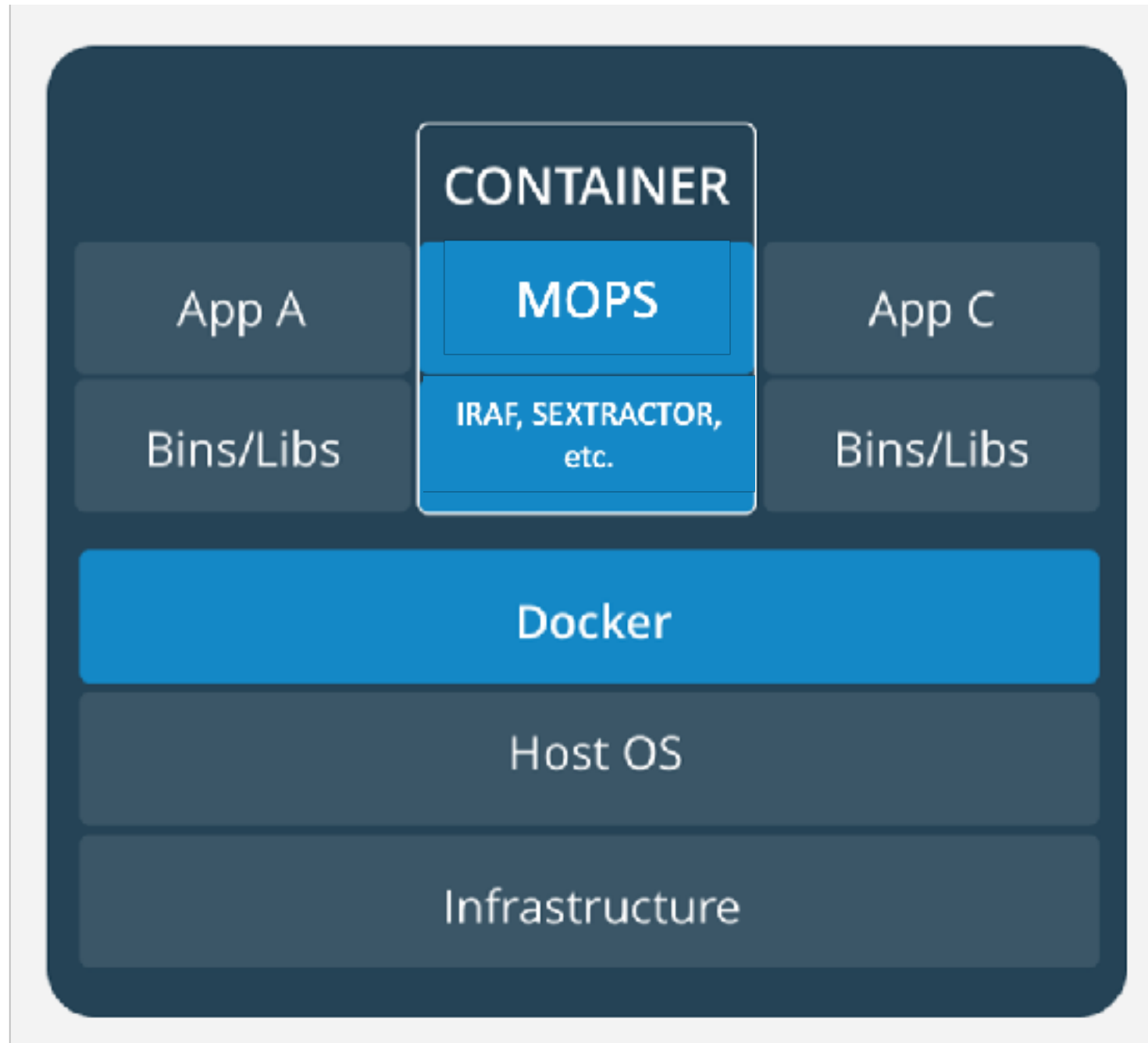
Architecture



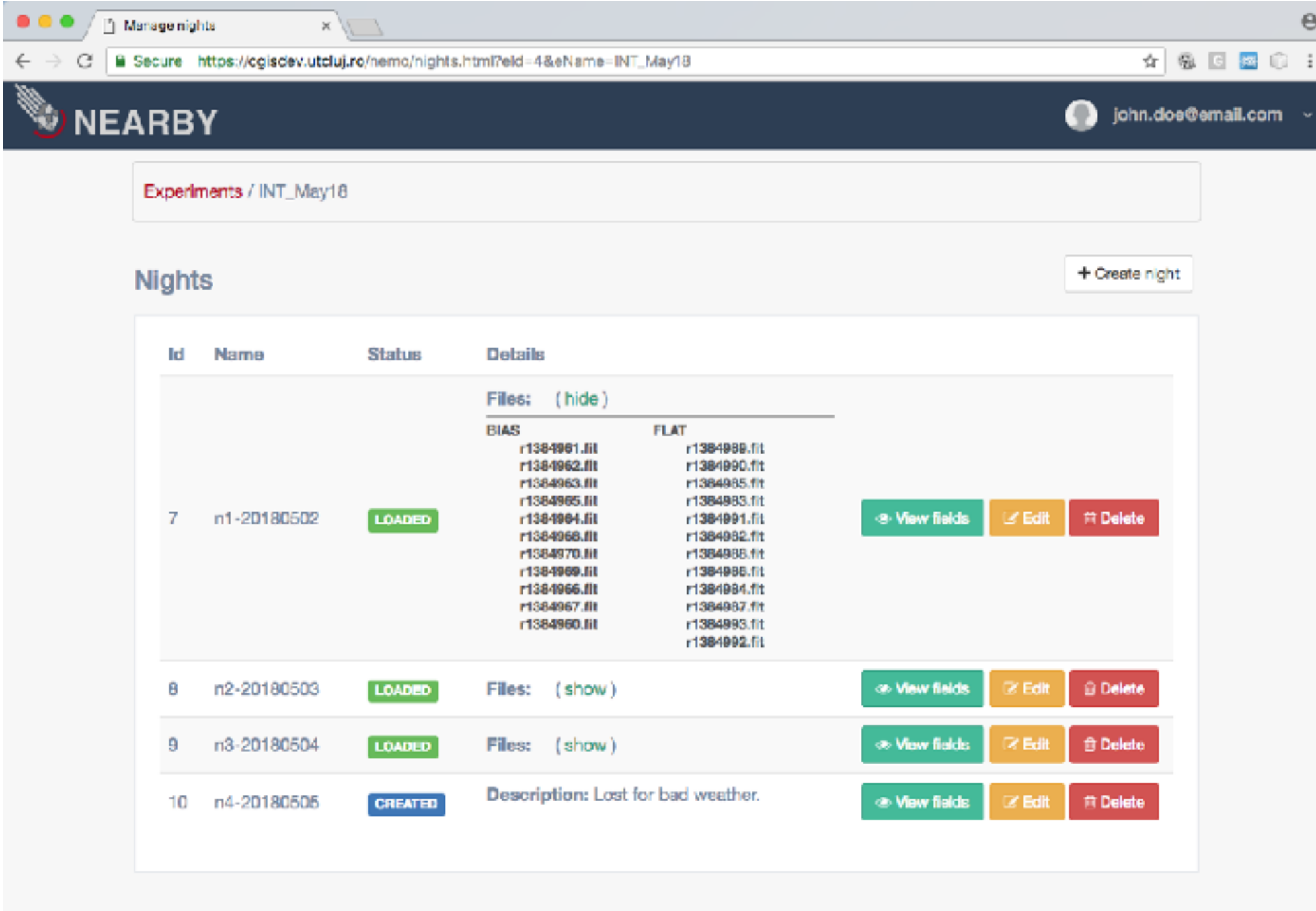
Technical requirements

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

Docker container



NEARBY@CloudUT UI



The screenshot shows a web browser window with the URL `https://cgisdev.utcluj.ro/nemo/nights.html?eld=4&eName=INT_May18`. The page header includes the NEARBY logo and a user profile for `john.doe@email.com`. The main content area is titled "Nights" and features a "+ Create night" button. Below this is a table with the following data:

Id	Name	Status	Details	
7	n1-20180502	LOADED	Files: (hide) BIAS r1384961.tif r1384962.tif r1384963.tif r1384965.tif r1384964.tif r1384968.tif r1384970.tif r1384969.tif r1384966.tif r1384967.tif r1384960.tif FLAT r1384989.tif r1384990.tif r1384985.tif r1384983.tif r1384991.tif r1384992.tif r1384988.tif r1384986.tif r1384984.tif r1384987.tif r1384993.tif r1384992.tif	View fields Edit Delete
8	n2-20180503	LOADED	Files: (show)	View fields Edit Delete
9	n3-20180504	LOADED	Files: (show)	View fields Edit Delete
10	n4-20180505	CREATED	Description: Lost for bad weather.	View fields Edit Delete

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NEARBY@CloudUT UI

Manage MPC Reports

Secure https://gitlabdev.utcluj.ro/nemo/mpc.html?eid=4&eName=INT_May18&nId=7&nName=n1-20180502&fid=88&fName=E101&pid=146&pName=PRJ02

EM00001

UNDEFINED: 0 VALID: 4 INVALID: 0

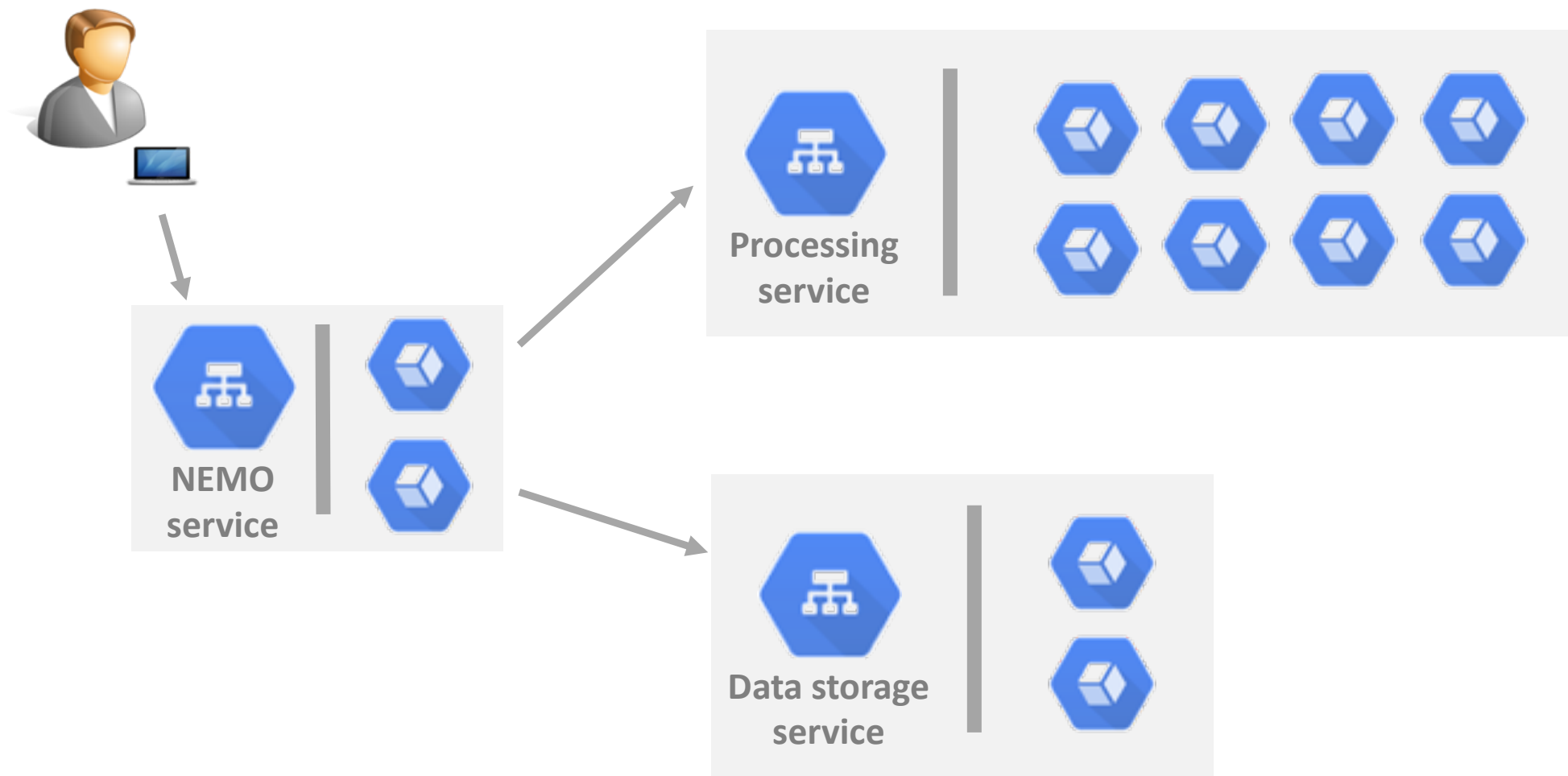
Details

MPC Info	E	FWHM	THETA	Status	Thumbnail
EM00001 C2018 05 02.88455 10 00 43.84 +12 10 40.0 21.8 R 950	0.38	2.38	54.10		Paused on: 1 / 4 Validate Object Invalidate Object
EM00001 C2018 05 02.89031 10 00 44.05 +12 10 39.6 21.4 R 950	0.26	1.51	53.73		 VALID Invalidate
EM00001 C2018 05 02.89605 10 00 44.14 +12 10 39.0 21.6 R 960	0.32	3.02	20.84		 VALID Invalidate
EM00001 C2018 05 02.90112 10 00 44.24 +12 10 38.4 21.8 R 960	0.18	1.55	20.77		

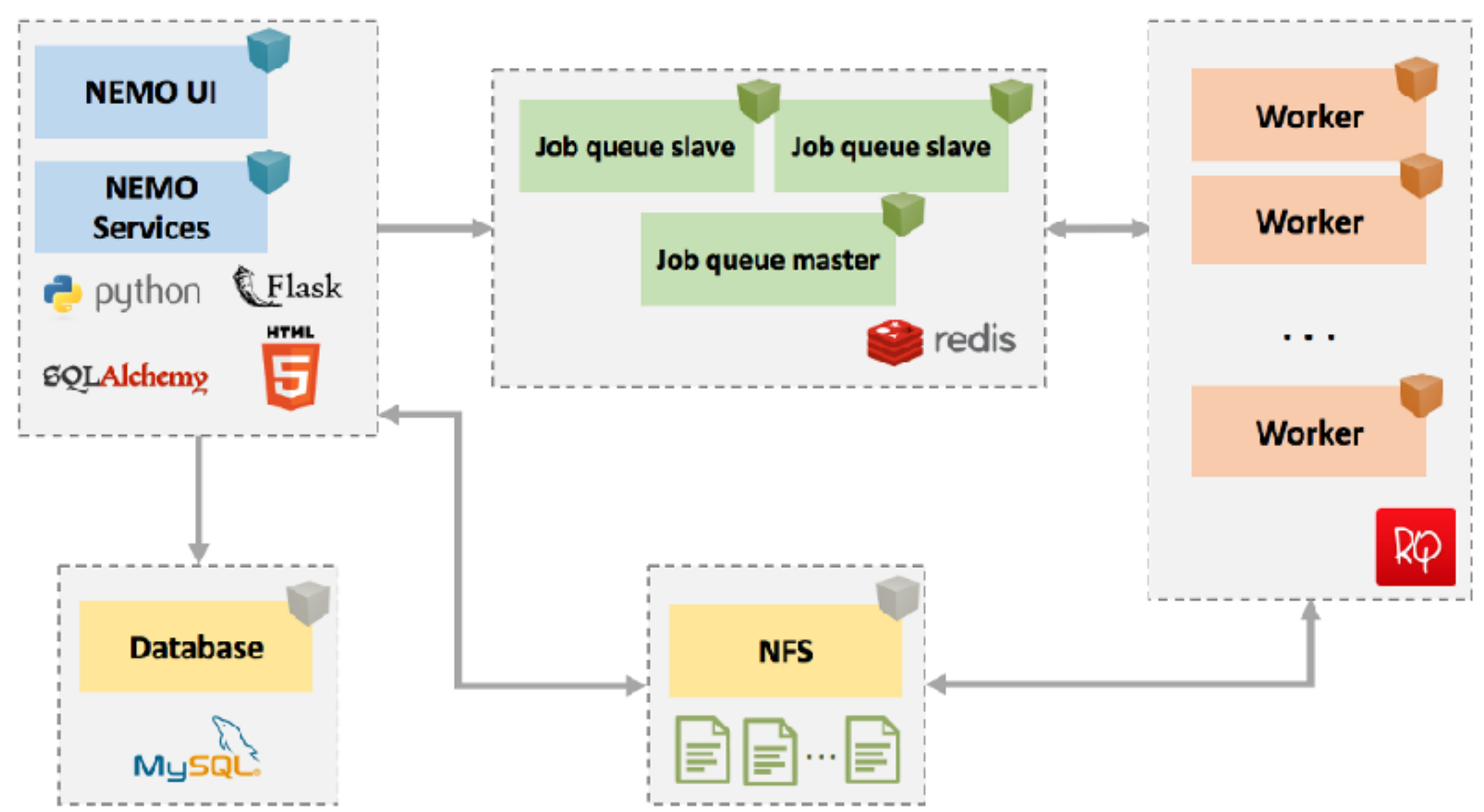
Trajectory: MIU = 0.20, PA = 250.1

Averages: 0.29 2.10 37.39

Services



Services



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

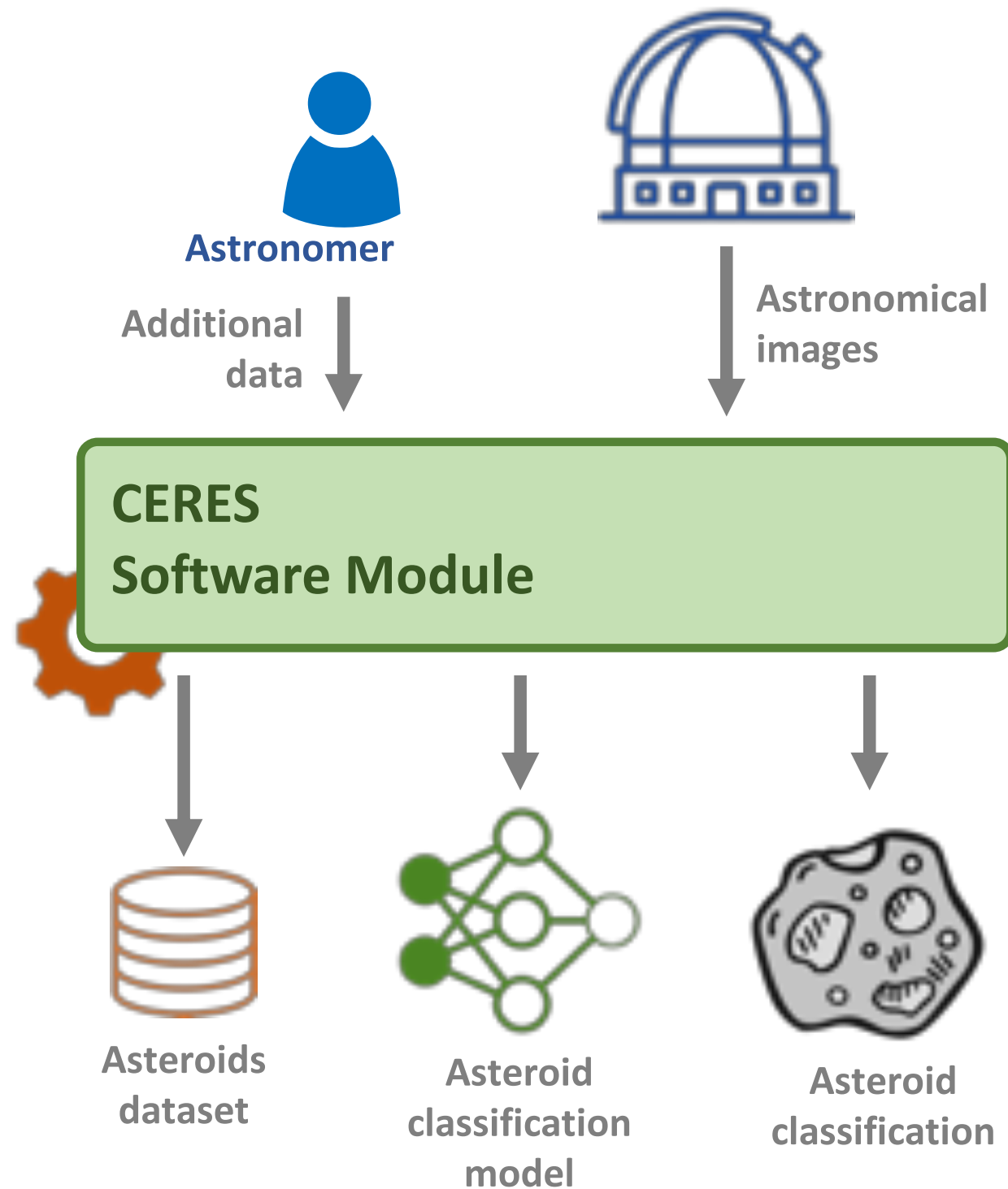
Autoritatea Contractantă:

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

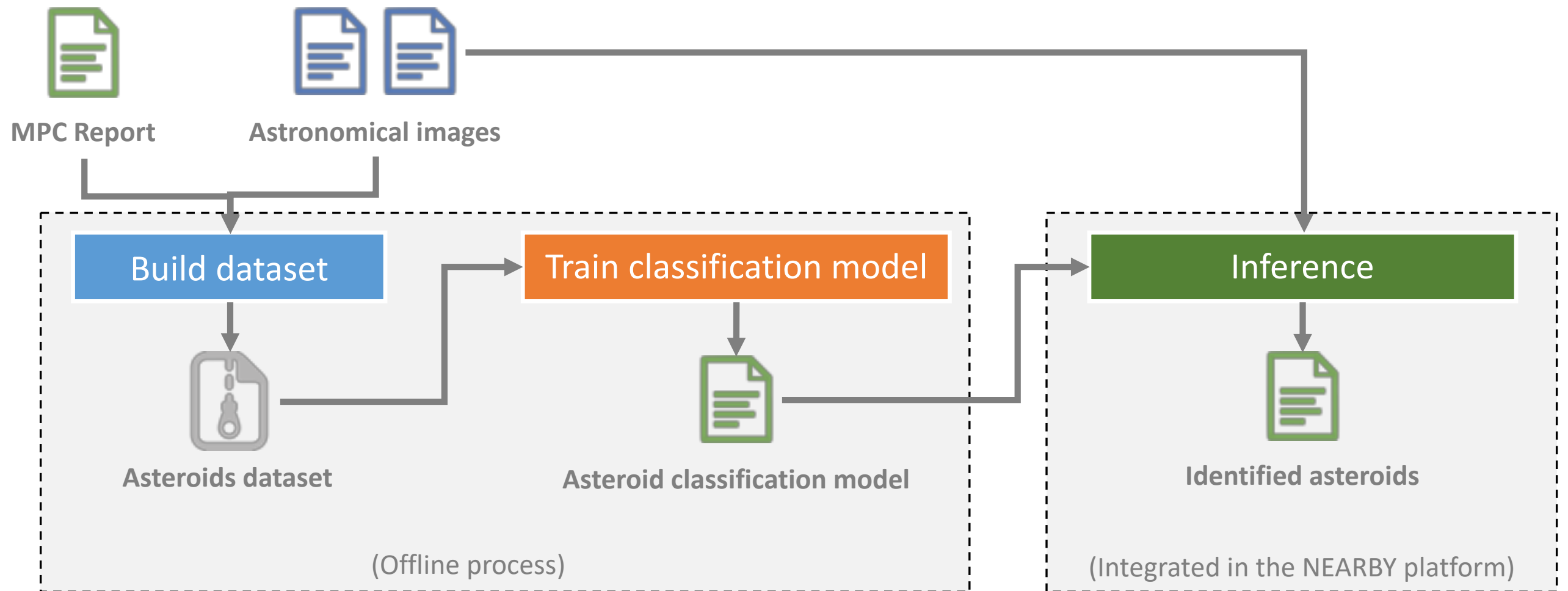
Objectives

- 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](#)

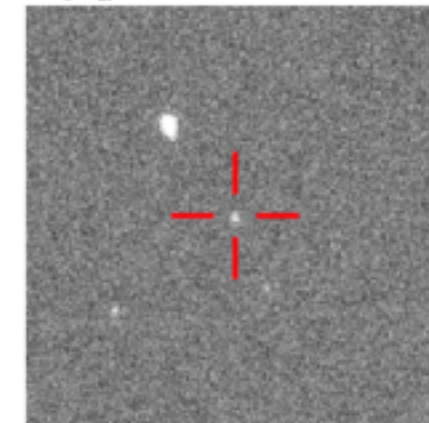
EM00006 C2018 09 17.19156 03 16 12.21 +26 19 57.3 21.4 R 950
EM00006 C2018 09 17.19997 03 16 12.16 +26 20 00.1 21.1 R 950
EM00006 C2018 09 17.20829 03 16 12.12 +26 20 03.0 21.1 R 950
EM00006 C2018 09 17.21667 03 16 12.10 +26 20 05.7 20.6 R 950
EM00006 C2018 09 17.22511 03 16 12.06 +26 20 08.6 21.0 R 950

Trajectory: MIU = 0.24, PA = 10.1

Averages: **E** **FWHM** **THETA**
0.31 1.58 13.87

E	FWHM	THETA
0.39	1.53	88.18
0.25	1.53	-80.74
0.28	1.51	85.11
0.37	1.89	-87.05
0.27	1.43	83.84
0.31	1.58	13.87

Playing: 3 / 5



[Validate Object](#)

[Invalidate Object](#)

[Prev](#)

[Next](#)

[Show lines details](#)



Invalid detection

EM00010

UNDEFINED: 0 VALID: 0 INVALID: 3

Details

Status Thumbnail

MPC Info [Copy](#)

EM00010 C2018 09 17.20829 03 15 14.36 +26 28 53.5 21.1 R 950
EM00010 C2018 09 17.21667 03 15 14.38 +26 28 49.3 21.4 R 950
EM00010 C2018 09 17.22511 03 15 14.35 +26 28 45.9 20.7 R 950

Trajectory: MIU = 0.32, PA = 177.6

	E	FWHM	THETA
	0.49	3.12	72.06
	0.57	2.24	37.72
	0.40	3.40	8.16
Averages:	0.49	2.92	39.31

Playing: 1 / 3



✓ Validate Object

✗ Invalidate Object

← Prev Next →

👁 Show lines details

Dataset

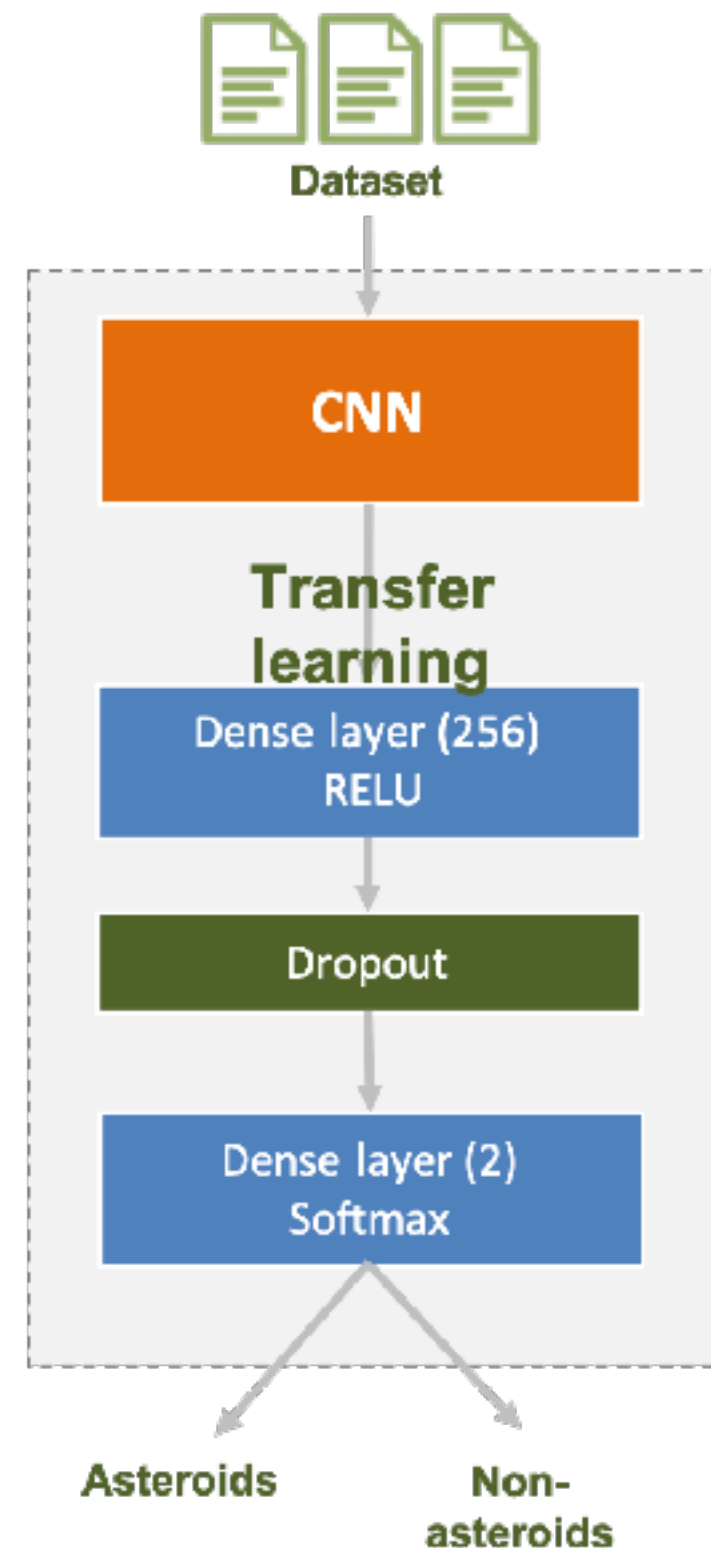
- **Input**
 - Preprocessed astronomical images (NEARBY)
 - MPC files containing detections validated by astronomers
 - SkyBot
- **Output - fits images (200 x 200 px)**
 - Valid detections (asteroids)
 - Valid detections by SkyBot but invalidated by astronomers
 - Valid detections by astronomers by invalidated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

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

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

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

Dataset

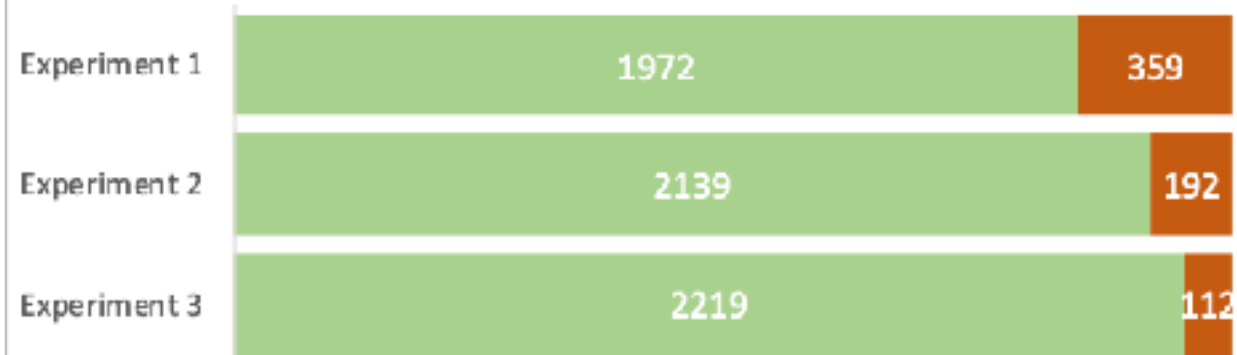
	Non-asteroid class	Asteroid class
Training set	38146	21733
Validation set	433	747
Test set	5983	2331

Results

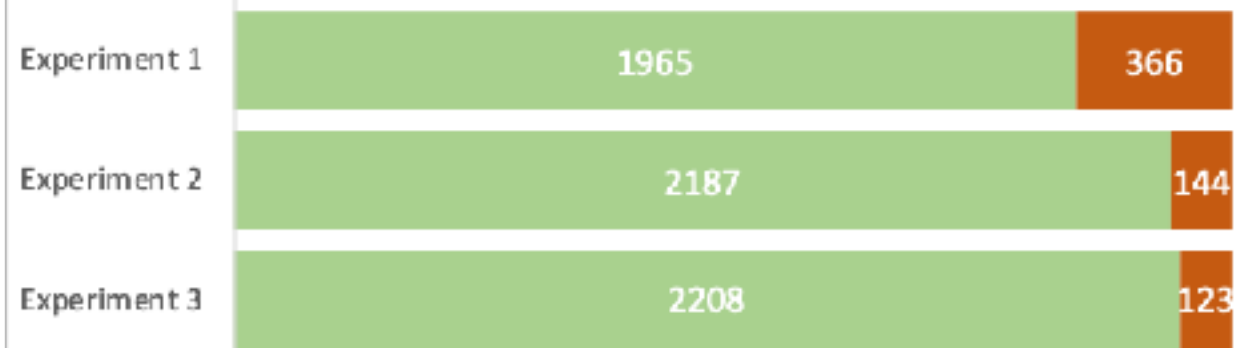
		InceptionV3		
		precision	recall	f1-score
Experiment 1	Non-asteroid class	0.94	0.88	0.91
	Asteroid class	0.73	0.85	0.79
Experiment 2	Non-asteroid class	0.97	0.92	0.94
	Asteroid class	0.82	0.92	0.86
Experiment 3	Non-asteroid class	0.98	0.91	0.94
	Asteroid class	0.81	0.95	0.87

Results

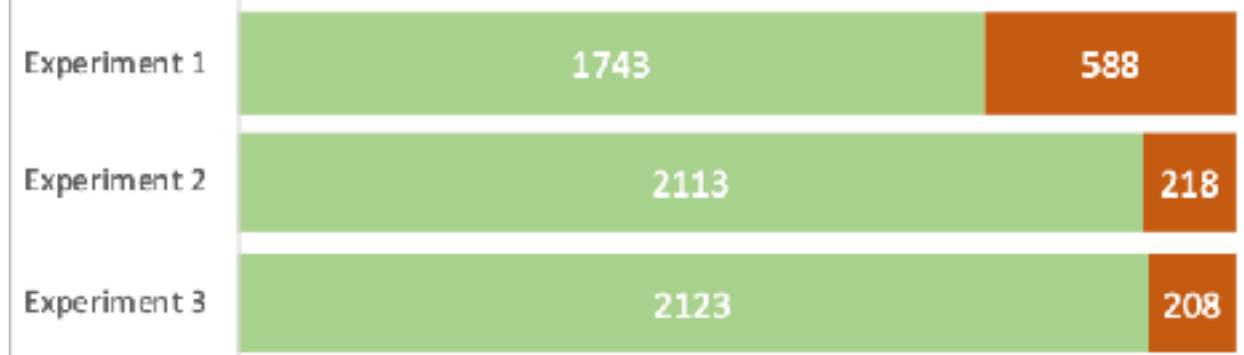
InceptionV3



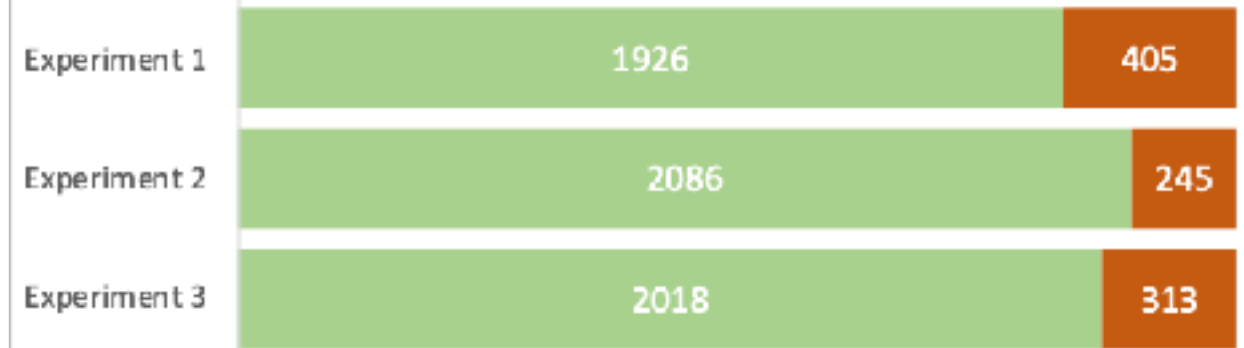
Xception



InceptionResNetV2



ResNet152V2



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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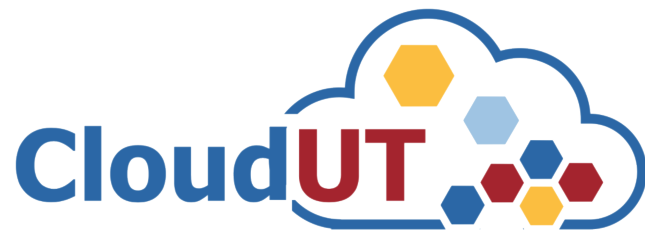


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Thanks! Questions?



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