POLYTECH
Peter the Great
St.Petersburg Polytechnic
University

Recognition of potholes on a road

Course Work Report:
Corporate Information Systems

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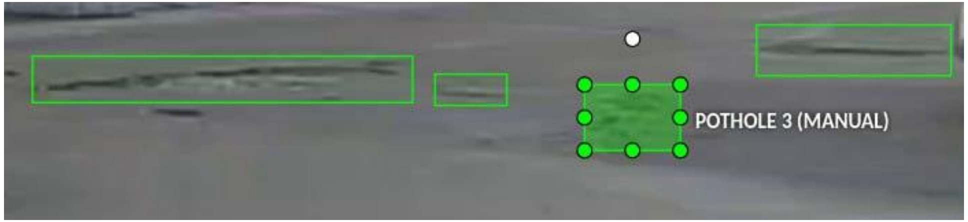
Project Goal

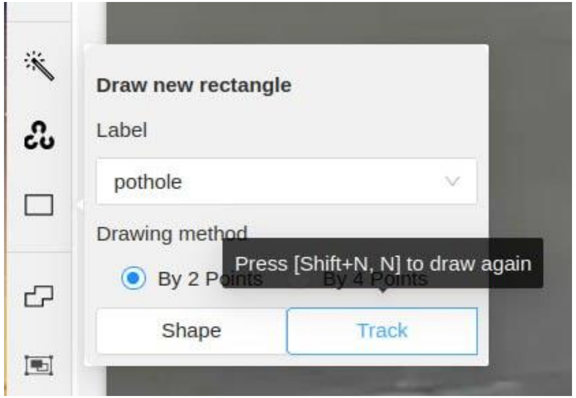
To develop a multi-agents system capable of detecting potholes in real time with a high degree of accuracy and with a sufficiently high processing speed, marking detected potholes as dangerous or relatively safe by their width in the image

Project Tasks

#1	Preparing a dataset	Looking for a dataset and labeling images
#2	Train the YOLOv8 model	Photos and Videos
#3	Develop a Knowledge Base	Knowledge base with consistency checking
#4	Develop API and clients	FastAPI backend + Telegram and Web App
#5	Integration and testing	FastAPI backend + Telegram and Web App

Dataset and Images labeling





Draw new rectangle

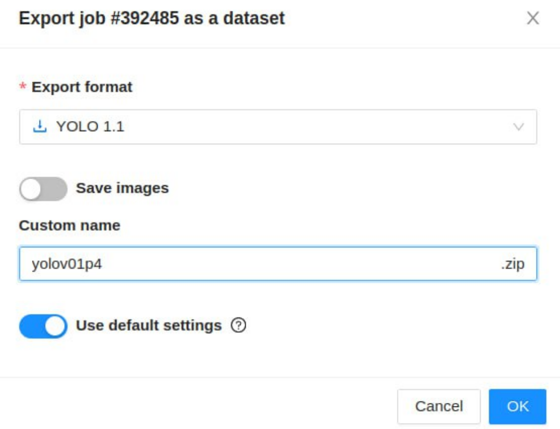
Label

pothole

Drawing method

● By 2 Points ○ By 4 Points

Press [Shift+N, N] to draw again



Export job #392485 as a dataset

* **Export format**

YOLO 1.1

Save images

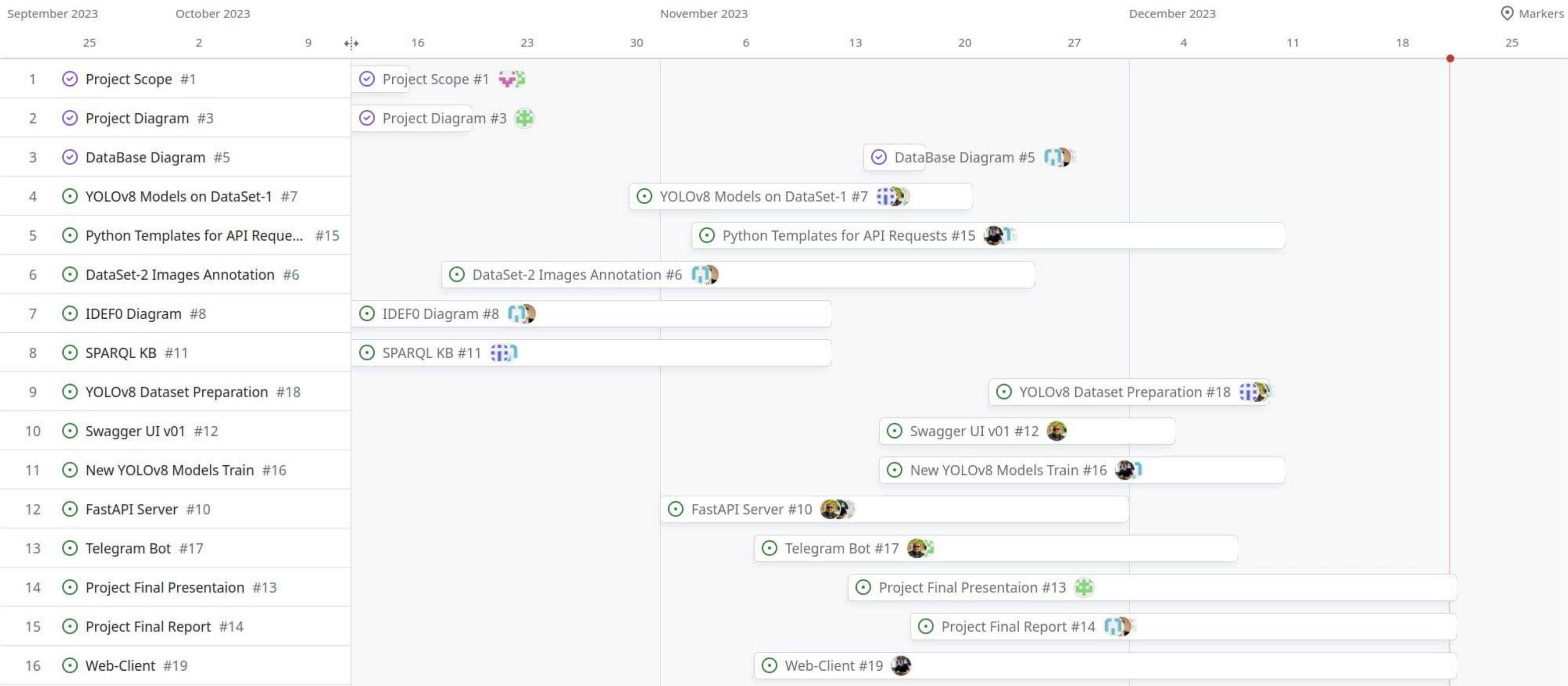
Custom name

yolov01p4 .zip

Use default settings

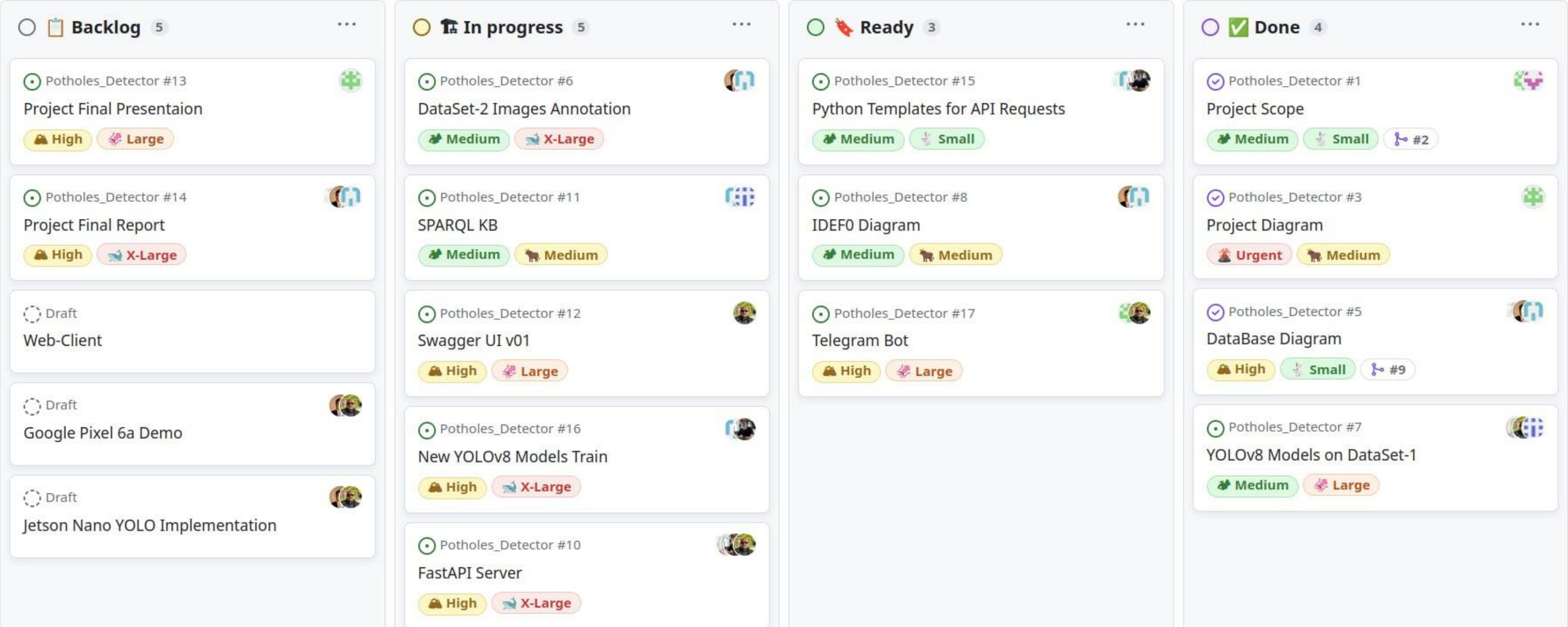
Project Diagrams

Gantt Chart



1	✓	Project Scope #1
2	✓	Project Diagram #3
3	✓	DataBase Diagram #5
4	⊙	YOLOv8 Models on DataSet-1 #7
5	⊙	Python Templates for API Reque... #15
6	⊙	DataSet-2 Images Annotation #6
7	⊙	IDEF0 Diagram #8
8	⊙	SPARQL KB #11
9	⊙	YOLOv8 Dataset Preparation #18
10	⊙	Swagger UI v01 #12
11	⊙	New YOLOv8 Models Train #16
12	⊙	FastAPI Server #10
13	⊙	Telegram Bot #17
14	⊙	Project Final Presentaion #13
15	⊙	Project Final Report #14
16	⊙	Web-Client #19

KANBAN Board



📋 Backlog 5

Potholes_Detector #13
Project Final Presentaion
High · Large

Potholes_Detector #14
Project Final Report
High · X-Large

Draft
Web-Client

Draft
Google Pixel 6a Demo

Draft
Jetson Nano YOLO Implementation

🏗 In progress 5

Potholes_Detector #6
DataSet-2 Images Annotation
Medium · X-Large

Potholes_Detector #11
SPARQL KB
Medium · Medium

Potholes_Detector #12
Swagger UI v01
High · Large

Potholes_Detector #16
New YOLOv8 Models Train
High · X-Large

Potholes_Detector #10
FastAPI Server
High · X-Large

🔖 Ready 3

Potholes_Detector #15
Python Templates for API Requests
Medium · Small

Potholes_Detector #8
IDEF0 Diagram
Medium · Medium

Potholes_Detector #17
Telegram Bot
High · Large

✅ Done 4

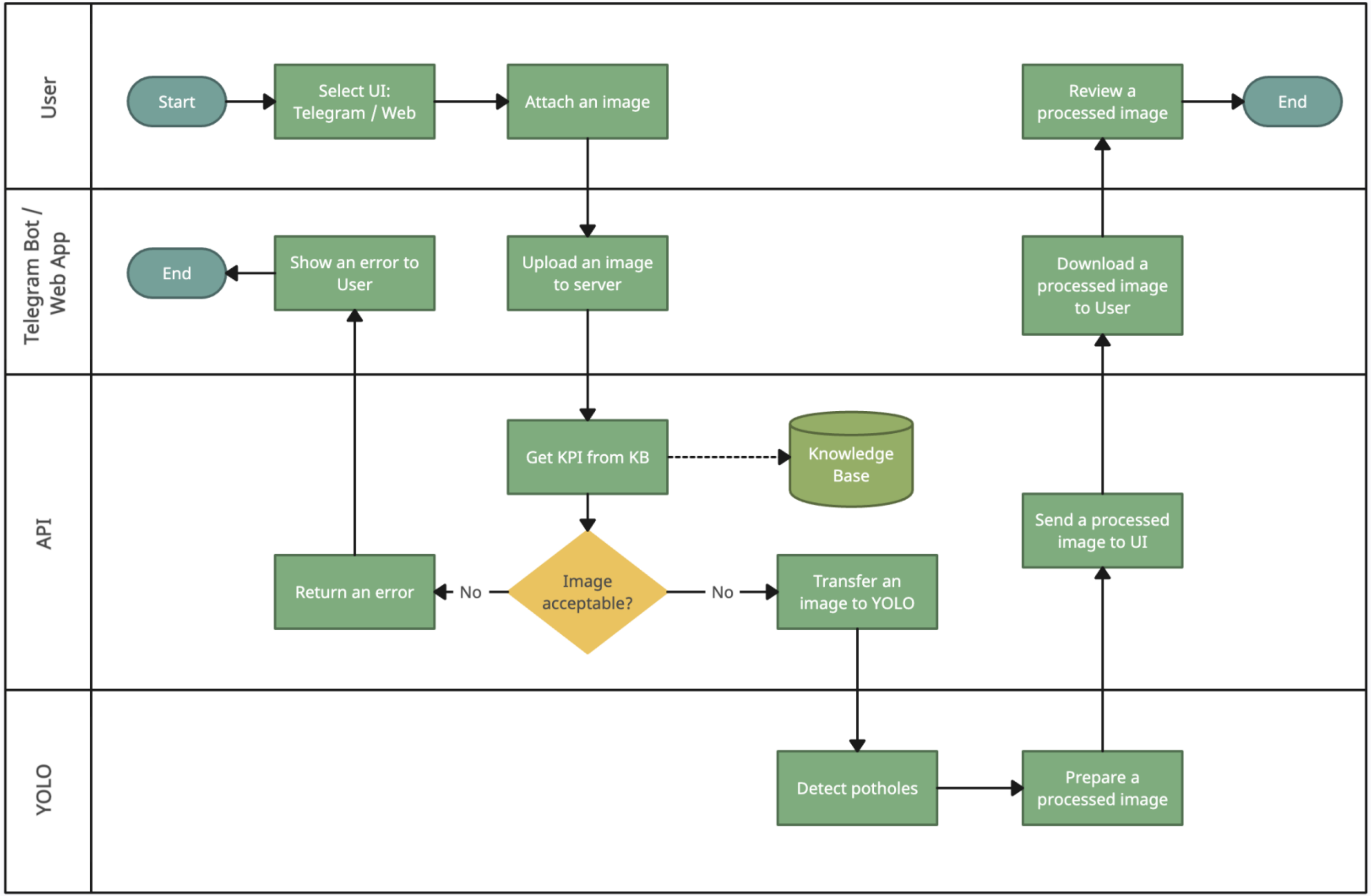
Potholes_Detector #1
Project Scope
Medium · Small · #2

Potholes_Detector #3
Project Diagram
Urgent · Medium

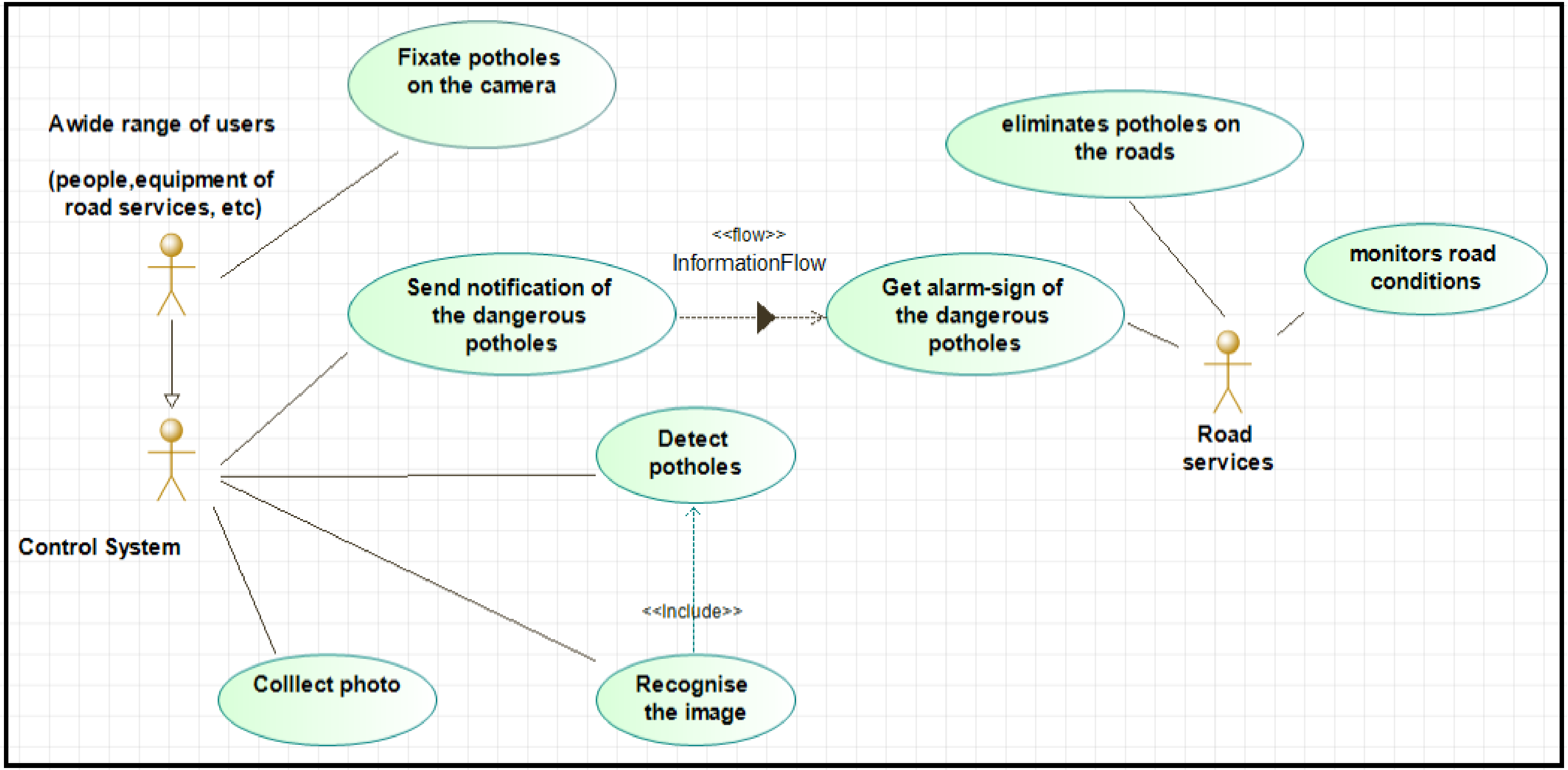
Potholes_Detector #5
DataBase Diagram
High · Small · #9

Potholes_Detector #7
YOLOv8 Models on DataSet-1
Medium · Large

Swimlane Diagram

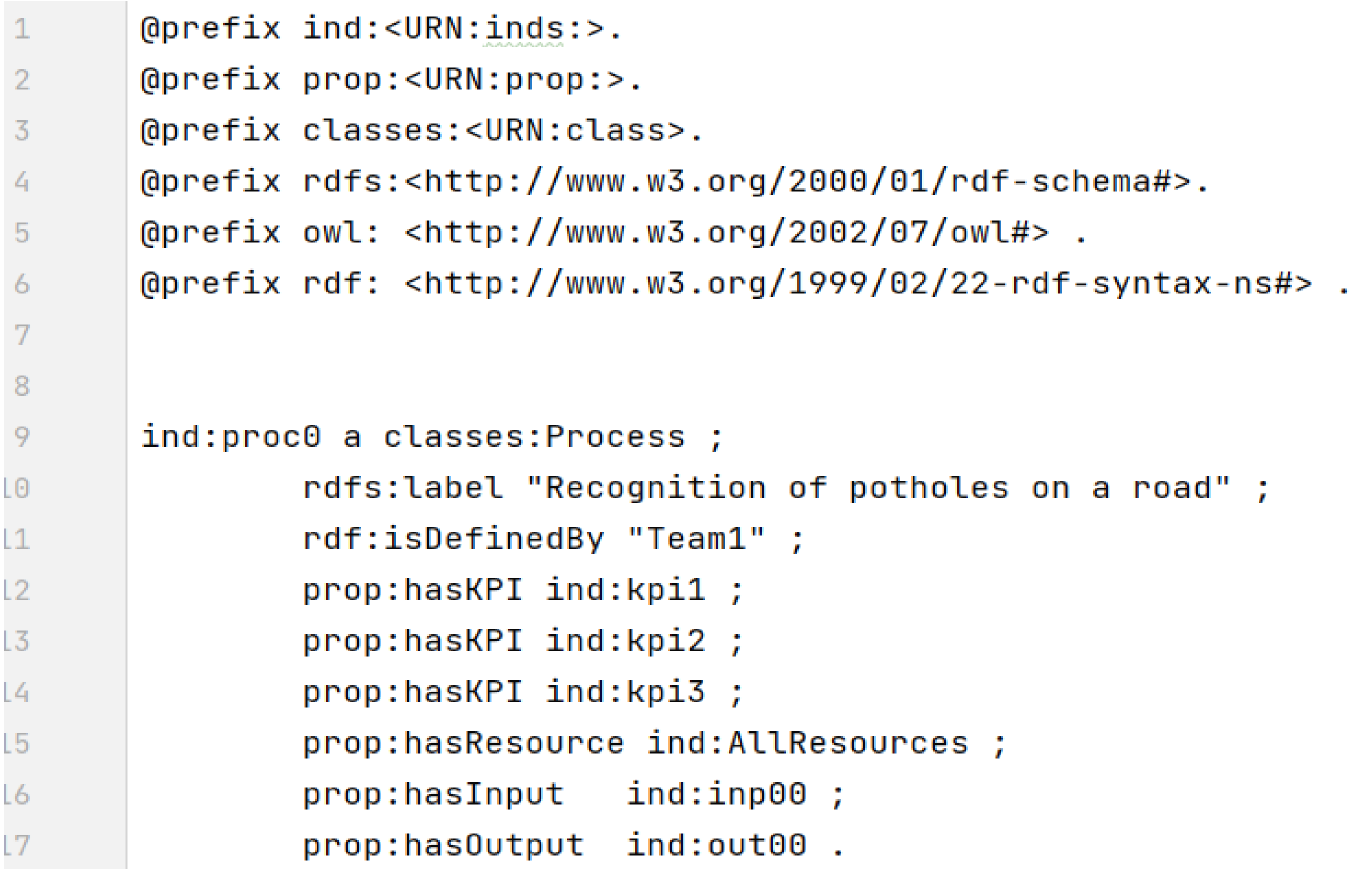

User
Telegram Bot / Web App
API
YOLO
Start
Select UI: Telegram / Web
Attach an image
Review a processed image
End
End
Show an error to User
Upload an image to server
Download a processed image to User
Get KPI from KB
Knowledge Base
Send a processed image to UI
Return an error
No
Image acceptable?
No
Transfer an image to YOLO
Detect potholes
Prepare a processed image

Use Case Diagram


Fixate potholes on the camera
Awide range of users
(people,equipment of road services, etc)
eliminates potholes on the roads
<<flow>>
InformationFlow
monitors road conditions
Send notification of the dangerous potholes
Get alarm-sign of the dangerous potholes
Road services
Detect potholes
Control System
<<Include>>
Colllect photo
Recognise the image

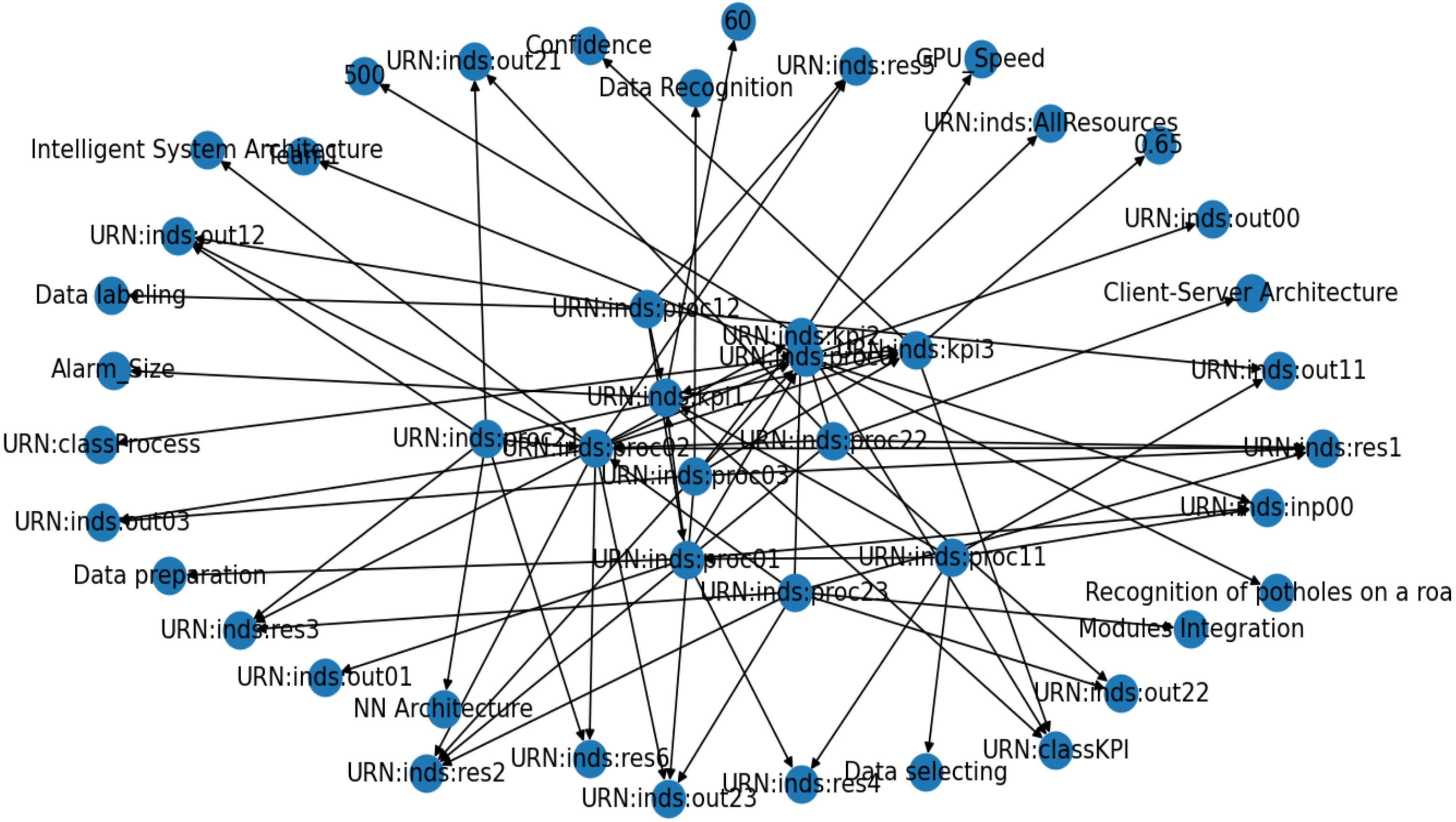
Knowledge Base
Rule Base
SPARQL

KB



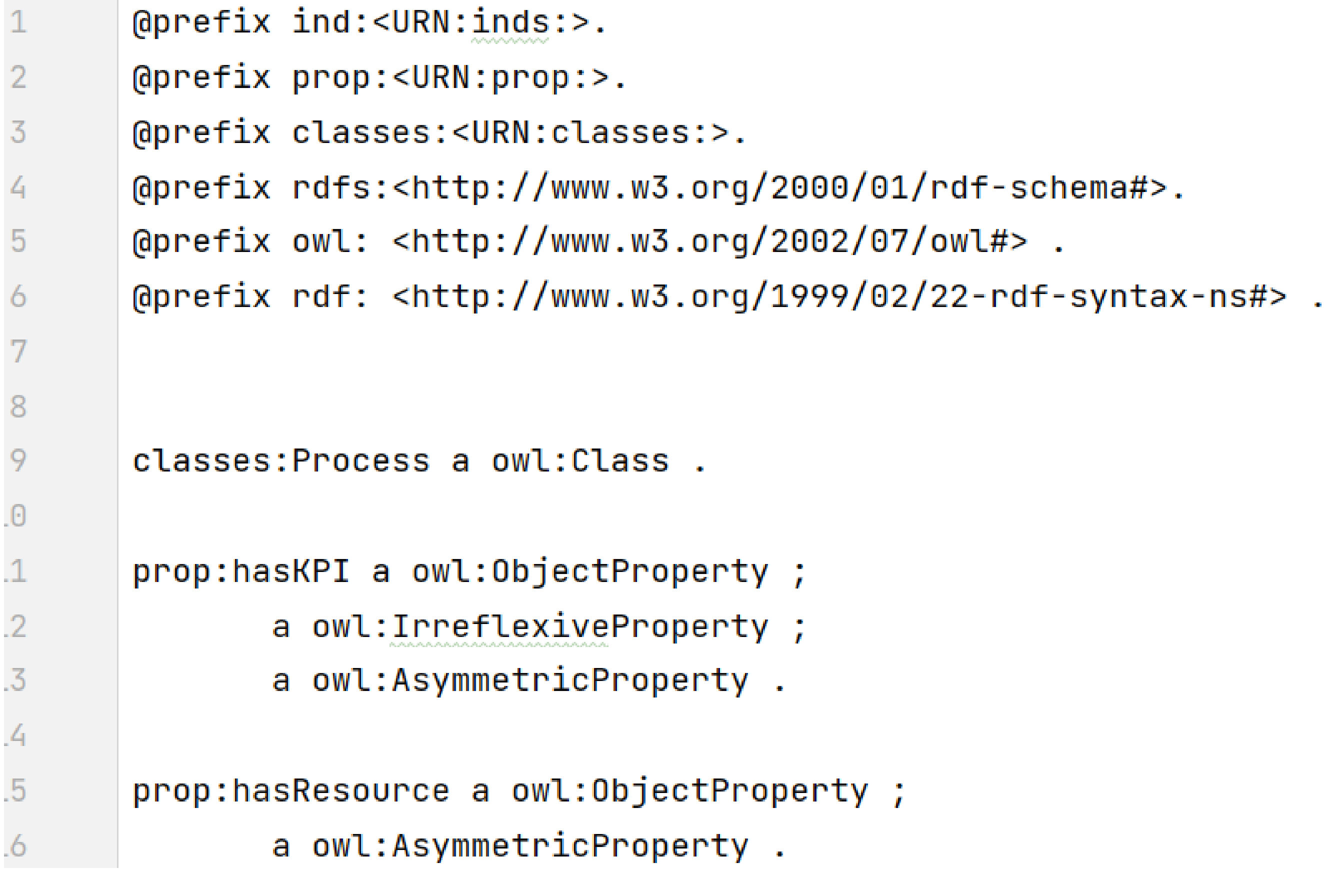
```
@prefix ind:<URN:inds:>.
@prefix prop:<URN:prop:>.
@prefix classes:<URN:class>.
@prefix rdfs:<http://www.w3.org/2000/01/rdf-schema#>.
@prefix owl: <http://www.w3.org/2002/07/owl#> .
@prefix rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#> .


ind:proc0 a classes:Process ;
        rdfs:label "Recognition of potholes on a road" ;
        rdf:isDefinedBy "Team1" ;
        prop:hasKPI ind:kpi1 ;
        prop:hasKPI ind:kpi2 ;
        prop:hasKPI ind:kpi3 ;
        prop:hasResource ind:AllResources ;
        prop:hasInput   ind:inp00 ;
        prop:hasOutput  ind:out00 .
```

KB



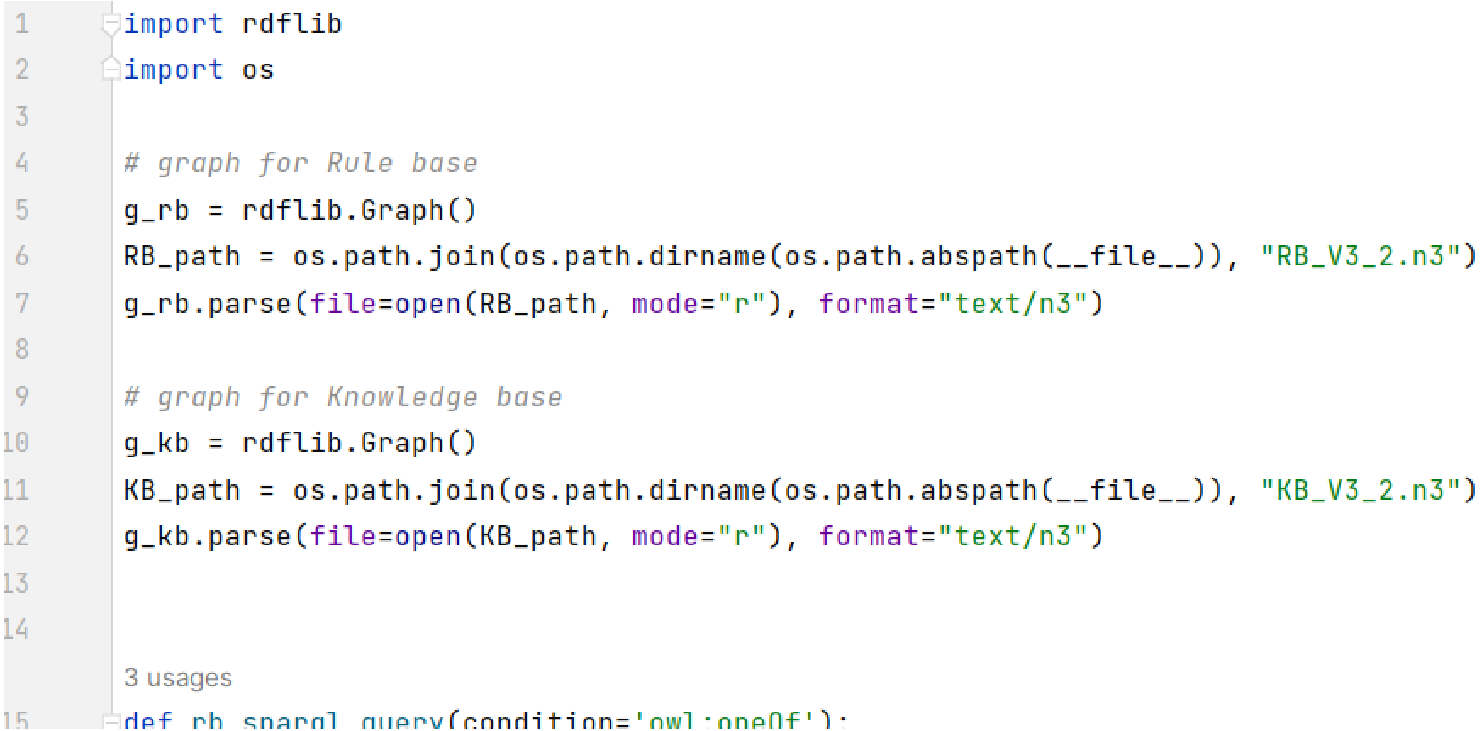
60
Confidence
500
URN:inds:out21
URN:inds:res5
GPU_Speed
Data Recognition
URN:inds:AllResources
0.65
Intelligent System Architecture
Team1
URN:inds:out00
URN:inds:out12
Client-Server Architecture
Data labeling
URN:inds:proc12
URN:inds:kpi2
URN:inds:proc00
URN:inds:kpi3
URN:inds:out11
Alarm_Size
URN:inds:kpi1
URN:classProcess
URN:inds:proc21
URN:inds:proc02
URN:inds:proc22
URN:inds:res1
URN:inds:proc03
URN:inds:inp00
URN:inds:out03
URN:inds:proc01
URN:inds:proc11
Data preparation
URN:inds:proc23
Recognition of potholes on a roa
URN:inds:res3
Modules Integration
URN:inds:out01
NN Architecture
URN:inds:out22
URN:classKPI
URN:inds:res6
URN:inds:res2
Data selecting
URN:inds:res4
URN:inds:out23

RB



```
@prefix ind:<URN:inds:>.
@prefix prop:<URN:prop:>.
@prefix classes:<URN:classes:>.
@prefix rdfs:<http://www.w3.org/2000/01/rdf-schema#>.
@prefix owl: <http://www.w3.org/2002/07/owl#> .
@prefix rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#> .


classes:Process a owl:Class .

prop:hasKPI a owl:ObjectProperty ;
       a owl:IrreflexiveProperty ;
       a owl:AsymmetricProperty .

prop:hasResource a owl:ObjectProperty ;
       a owl:AsymmetricProperty .
```

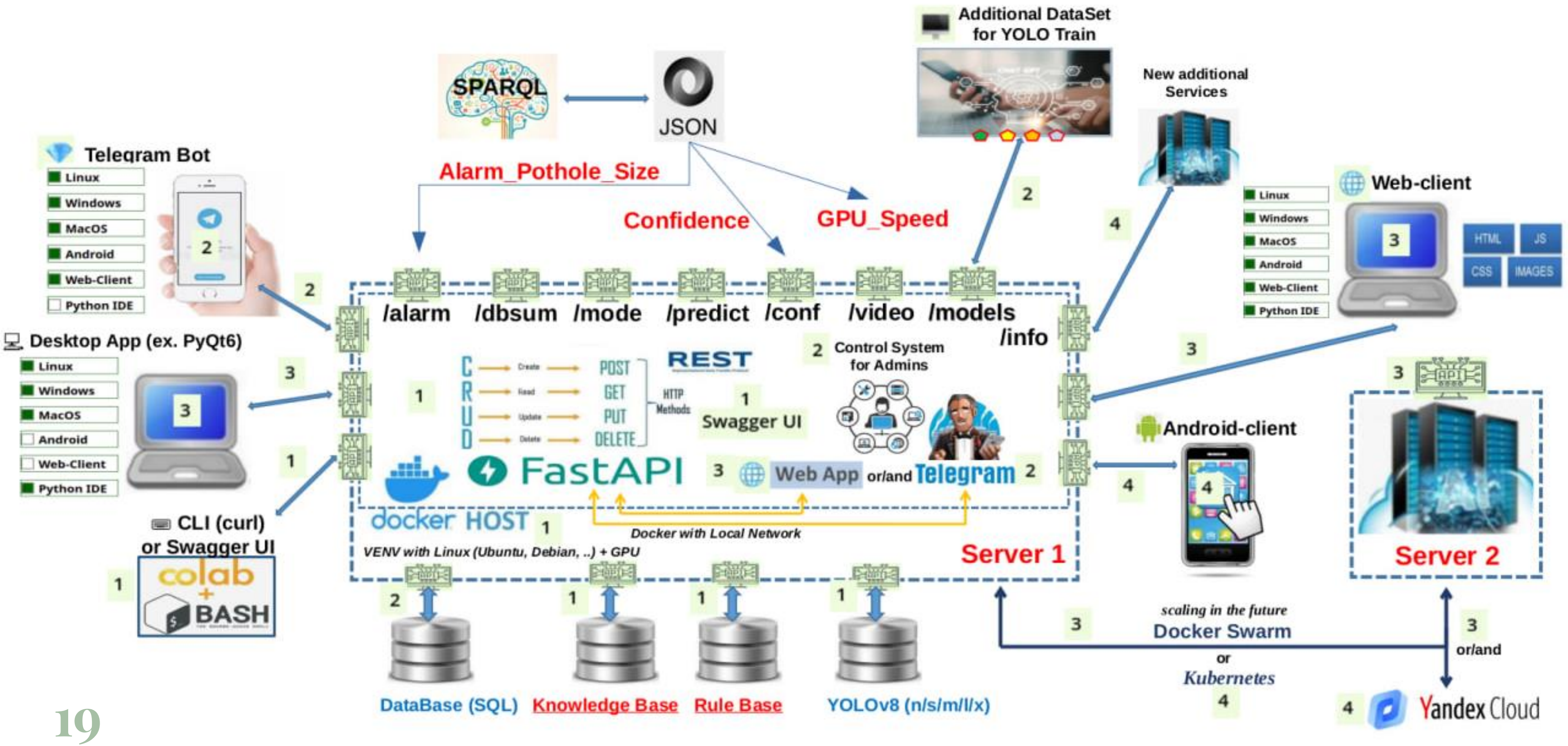
SPARQ



```python
import rdflib
import os

# graph for Rule base
g_rb = rdflib.Graph()
RB_path = os.path.join(os.path.dirname(os.path.abspath(__file__)), "RB_V3_2.n3")
g_rb.parse(file=open(RB_path, mode="r"), format="text/n3")

# graph for Knowledge base
g_kb = rdflib.Graph()
KB_path = os.path.join(os.path.dirname(os.path.abspath(__file__)), "KB_V3_2.n3")
g_kb.parse(file=open(KB_path, mode="r"), format="text/n3")


3 usages
def rb_sparql_query(condition='owl:oneOf'):
```

Key Technologies

Multi-agent API Solution



Telegram Bot

- ■ Linux
- ■ Windows
- ■ MacOS
- ■ Android
- ■ Web-Client
- □ Python IDE

2

2

Desktop App (ex. PyQt6)

- ■ Linux
- ■ Windows
- ■ MacOS
- □ Android
- □ Web-Client
- ■ Python IDE

3

3

1

CLI (curl) or Swagger UI

1

colab + BASH

SPARQL

JSON

Alarm_Pothole_Size

Confidence

GPU_Speed

Additional DataSet for YOLO Train

2

New additional Services

4

/alarm /dbsum /mode /predict /conf /video /models /info

1

C Create POST
R Read GET
U Update PUT
D Delete DELETE

HTTP Methods

REST

1 Swagger UI

2 Control System for Admins

FastAPI

3 Web App or/and Telegram 2

docker HOST 1

Docker with Local Network

VENV with Linux (Ubuntu, Debian, ..) + GPU

Server 1

2 DataBase (SQL)

1 Knowledge Base

1 Rule Base

1 YOLOv8 (n/s/m/l/x)

Web-client

- ■ Linux
- ■ Windows
- ■ MacOS
- ■ Android
- ■ Web-Client
- ■ Python IDE

3

HTML JS CSS IMAGES

3

Android-client

4

4

3

Server 2

3

scaling in the future

Docker Swarm

or

Kubernetes

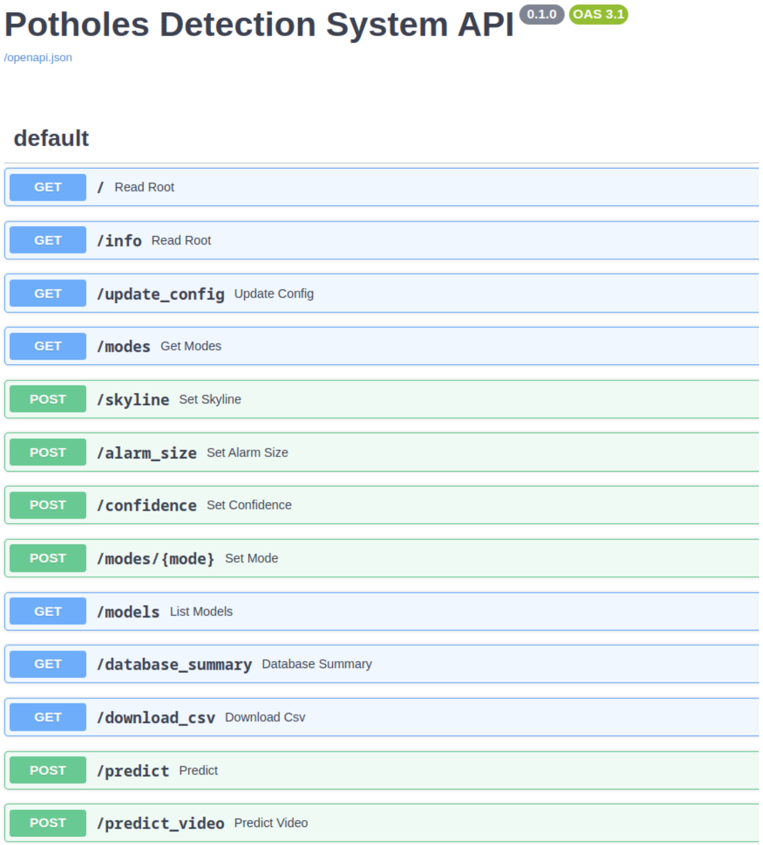
4

3

or/and

4 Yandex Cloud

FastAPI and Swagger

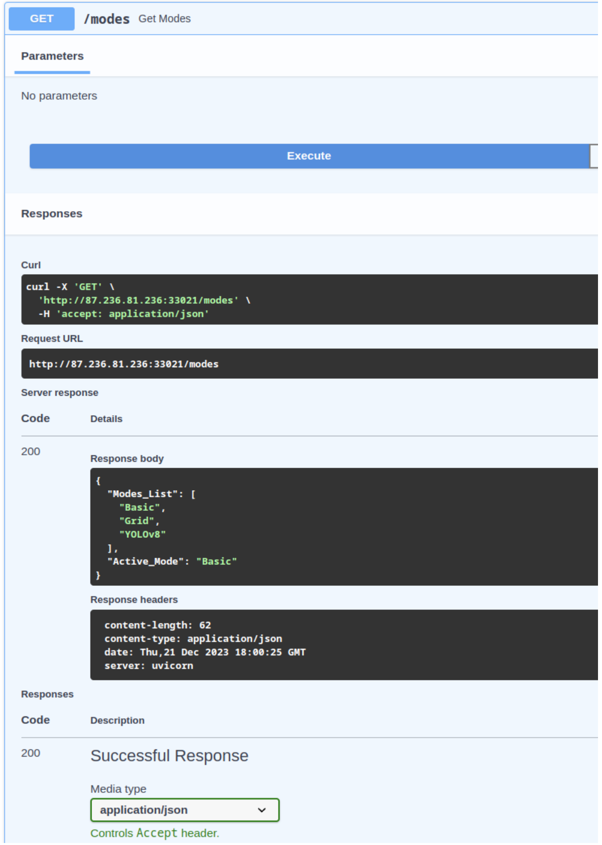


Potholes Detection System API 0.1.0 OAS 3.1

/openapi.json

default

- GET / Read Root
- GET /info Read Root
- GET /update_config Update Config
- GET /modes Get Modes
- POST /skyline Set Skyline
- POST /alarm_size Set Alarm Size
- POST /confidence Set Confidence
- POST /modes/{mode} Set Mode
- GET /models List Models
- GET /database_summary Database Summary
- GET /download_csv Download Csv
- POST /predict Predict
- POST /predict_video Predict Video



GET /modes Get Modes

Parameters

No parameters

Execute

Responses

Curl

```
curl -X 'GET' \
  'http://87.236.81.236:33021/modes' \
  -H 'accept: application/json'
```

Request URL

```
http://87.236.81.236:33021/modes
```

Server response

Code	Details
200	Response body

```
{
  "Modes_List": [
    "Basic",
    "Grid",
    "YOLOv8"
  ],
  "Active_Mode": "Basic"
}
```

Response headers

```
content-length: 62
content-type: application/json
date: Thu,21 Dec 2023 18:00:25 GMT
server: uvicorn
```

Responses

Code	Description
200	Successful Response

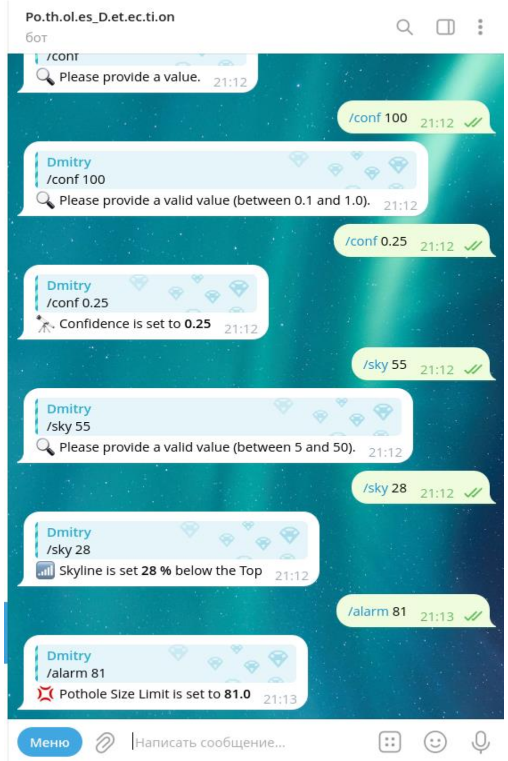
Media type

application/json

Controls Accept header.

User Interfaces

UI: Telegram Bot



/conf
Please provide a value. 21:12

/conf 100 21:12

Dmitry
/conf 100
Please provide a valid value (between 0.1 and 1.0). 21:12

/conf 0.25 21:12

Dmitry
/conf 0.25
Confidence is set to **0.25** 21:12

/sky 55 21:12

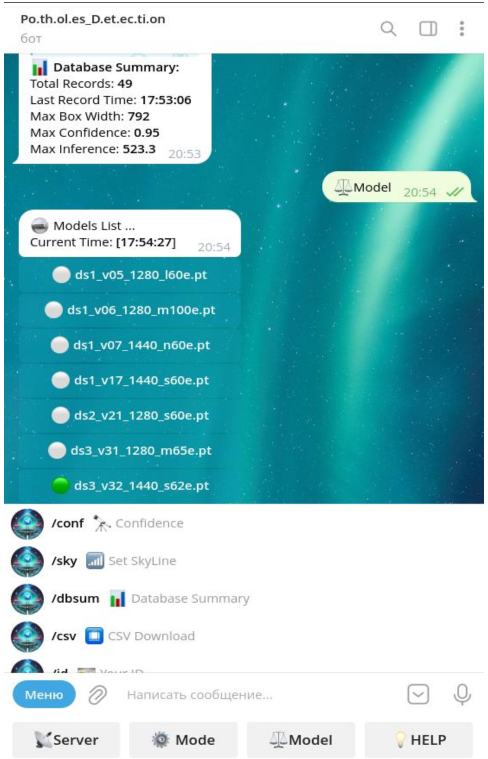
Dmitry
/sky 55
Please provide a valid value (between 5 and 50). 21:12

/sky 28 21:12

Dmitry
/sky 28
Skyline is set **28 %** below the Top 21:12

/alarm 81 21:13

Dmitry
/alarm 81
Pothole Size Limit is set to **81.0** 21:13

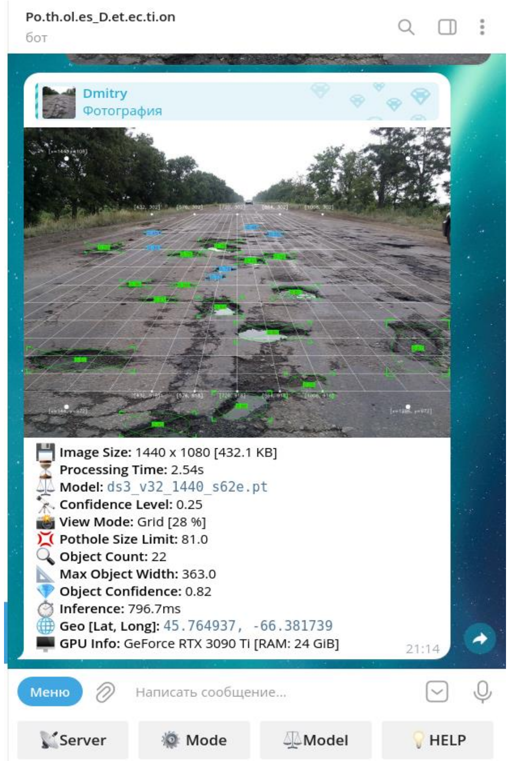


Database Summary:
Total Records: **49**
Last Record Time: **17:53:06**
Max Box Width: **792**
Max Confidence: **0.95**
Max Inference: **523.3** 20:53

Model 20:54

Models List ...
Current Time: **[17:54:27]** 20:54

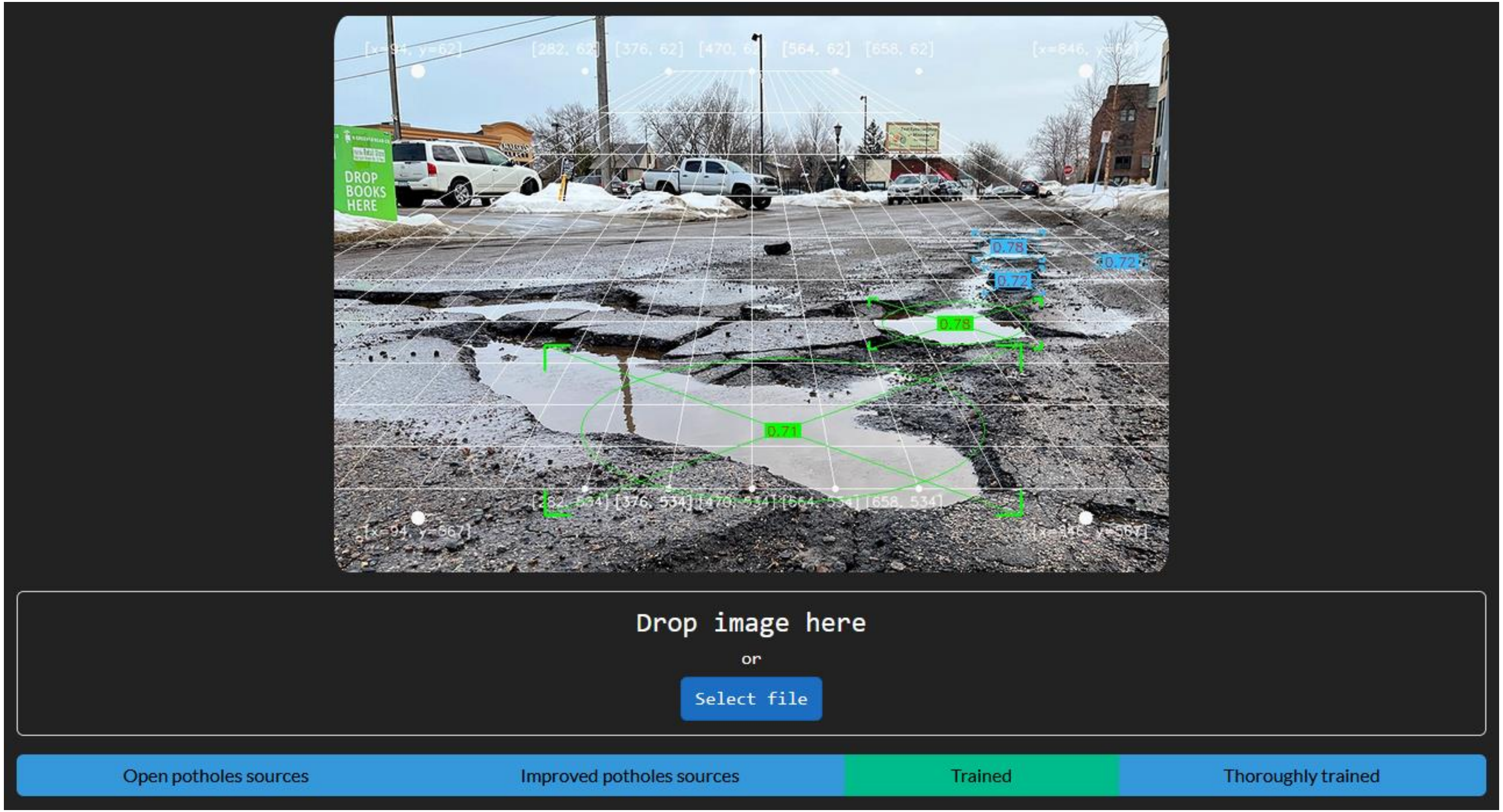
○ ds1_v05_1280_l60e.pt
○ ds1_v06_1280_m100e.pt
○ ds1_v07_1440_n60e.pt
○ ds1_v17_1440_s60e.pt
○ ds2_v21_1280_s60e.pt
○ ds3_v31_1280_m65e.pt
● ds3_v32_1440_s62e.pt



Dmitry
Фотография

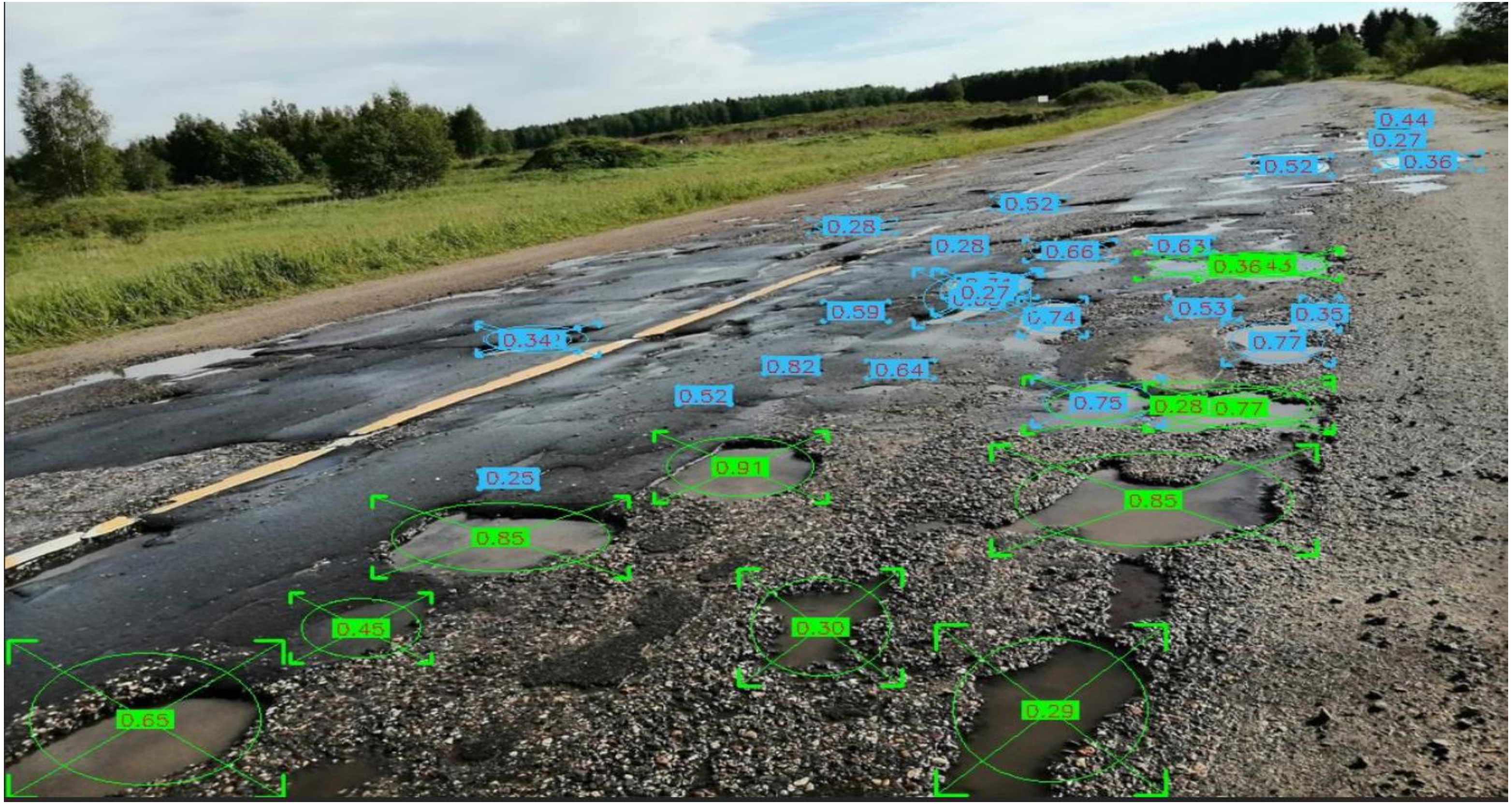
Image Size: 1440 x 1080 [432.1 KB]
Processing Time: 2.54s
Model: `ds3_v32_1440_s62e.pt`
Confidence Level: 0.25
View Mode: Grid [28 %]
Pothole Size Limit: 81.0
Object Count: 22
Max Object Width: 363.0
Object Confidence: 0.82
Inference: 796.7ms
Geo [Lat, Long]: `45.764937, -66.381739`
GPU Info: GeForce RTX 3090 Ti [RAM: 24 GiB] 21:14

UI: Web Application



Examples of Output

Example #1


0.44
0.27
0.36
0.52
0.52
0.28
0.28
0.66
0.63
0.36
0.27
0.59
0.74
0.53
0.35
0.34
0.77
0.82
0.64
0.52
0.75
0.28
0.77
0.25
0.91
0.85
0.85
0.45
0.30
0.65
0.29

Example #2

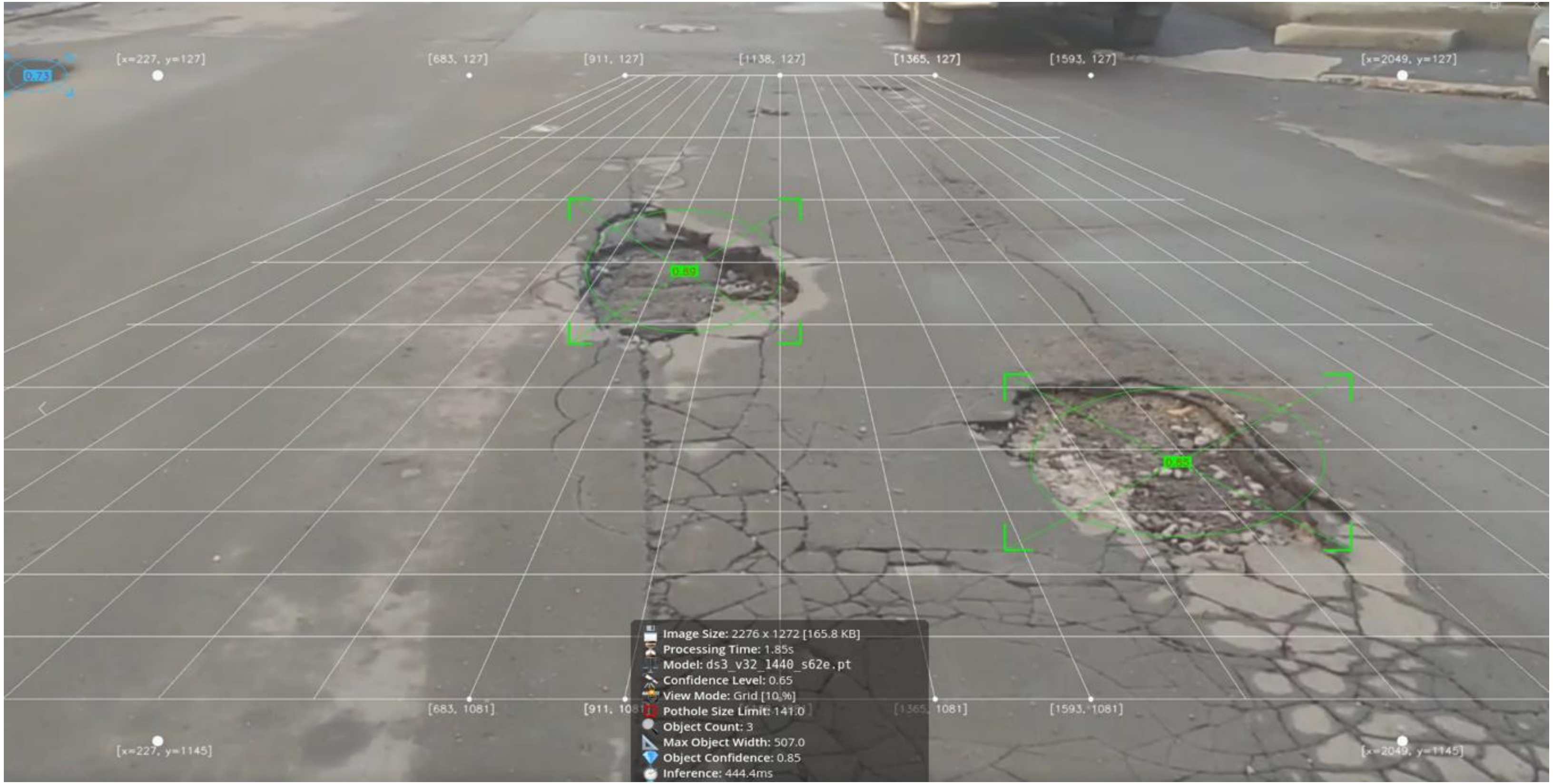


Image Size: 2276 x 1272 [165.8 KB]
Processing Time: 1.85s
Model: ds3_v32_1440_s62e.pt
Confidence Level: 0.65
View Mode: Grid [10 %]
Pothole Size Limit: 141.0
Object Count: 3
Max Object Width: 507.0
Object Confidence: 0.85
Inference: 444.4ms

KPI's

>60px

Width

>0.65

Confidence

<500ms

Processing Time

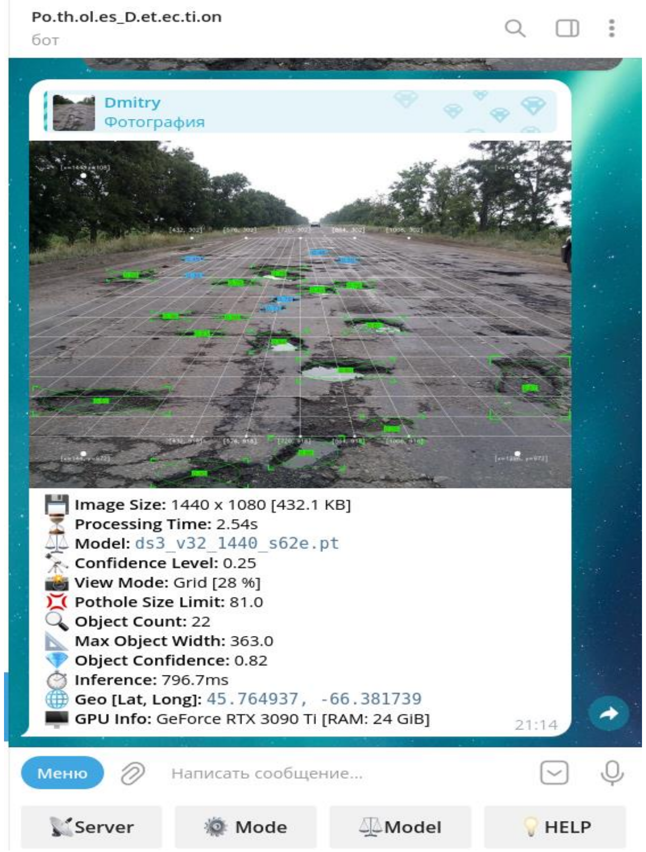


Image Size: 1440 x 1080 [432.1 KB]
Processing Time: 2.54s
Model: `ds3_v32_1440_s62e.pt`
Confidence Level: 0.25
View Mode: Grid [28 %]
Pothole Size Limit: 81.0
Object Count: 22
Max Object Width: 363.0
Object Confidence: 0.82
Inference: 796.7ms
Geo [Lat, Long]: `45.764937, -66.381739`
GPU Info: GeForce RTX 3090 Ti [RAM: 24 GiB]

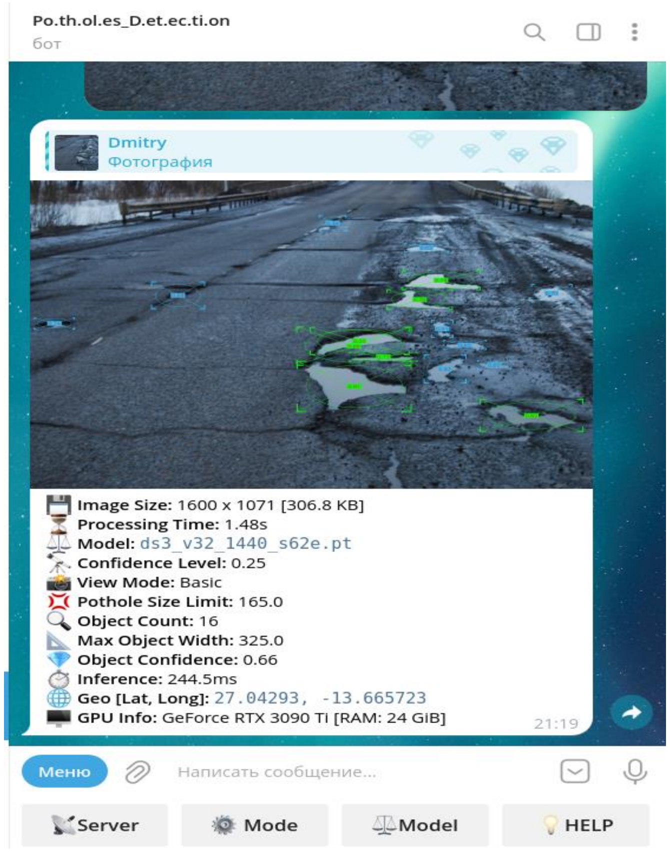


Image Size: 1600 x 1071 [306.8 KB]
Processing Time: 1.48s
Model: `ds3_v32_1440_s62e.pt`
Confidence Level: 0.25
View Mode: Basic
Pothole Size Limit: 165.0
Object Count: 16
Max Object Width: 325.0
Object Confidence: 0.66
Inference: 244.5ms
Geo [Lat, Long]: `27.04293, -13.665723`
GPU Info: GeForce RTX 3090 Ti [RAM: 24 GiB]

Achived Quality metrics for the YOLOv8

96,1%

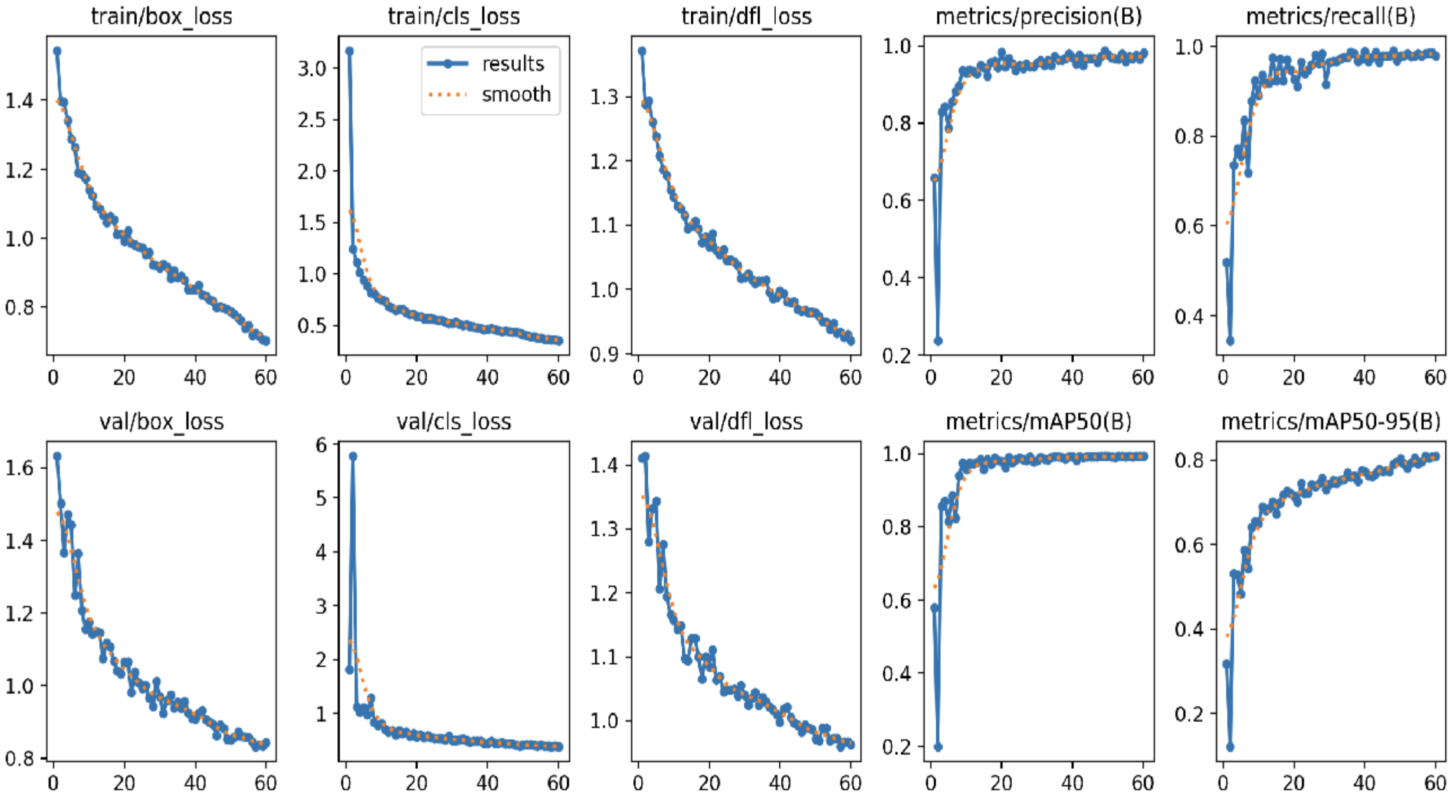
Precision

99,2%

Recall

97,6%

F1 Score



Plans

Future Plans and Developments

Enhancing Model Robustness

Scaling the System

Expanding Functionality

Conclusion

Conclusion

Successful Implementations

Effective Pothole Detection

Real-Time Processing and Feedback

User-Friendly Interface

Challenges and Unsuccessful Attempts

Handling Varied Lighting and Weather Conditions

Scalability Issues

Insights Gained

Importance of Data Quality

Importance of API in Progressive Development

User-Centric Design

Thanks!