National Technical University of Ukraine
"Igor Sikorsky Kyiv Polytechnic Institute"

Automation Hardware and Software Department

AI and Robotic as the means to overcome arising global challenges and everyday issues

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Kyiv polytechnic institute (since 2016 – National Technical University of Ukraine "Igor Sikorsky Kyiv Polytechnic Institute") was founded in 1898.

It trains **more than 25 thousand** of students, postgraduates; doctorates as well as foreign student from neighbouring and far abroad countries.

It has 16 faculties, 11 educational and scientific institutes, several scientific and research institutes and educational centers.

Automation Hardware and software Department (build. No19)

[https://tpza.kpi.ua]

Main University building (No1)

[https://kpi.ua/]

Automation Hardware and Software Department, National Technical University of Ukraine "Igor Sikorsky Kyiv Polytechnic Institute"

The most famous graduates are:

Igor Sikorsky was studying in KPI in 1907-1911. while studying at the university, he designed and built his first aircraft. It was at the university that he began building his first helicopter, then he has moved to US and in 1923 founded his own company - the Sikorsky Aircraft Corporation

(1889 – 1972)
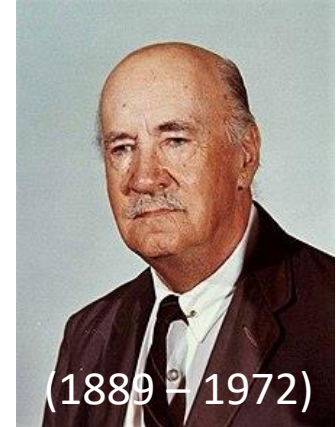
[https://en.wikipedia.org/wiki/Igor_Sikorsky]

Evgeny Paton, the inventor of electrical welding. He created methods used in the design of rational bridge spans, investigated the conditions of their operation, and suggested methods for restoring damaged bridges. He carried out research on the fundamentals of welding, how to calculate the strength of welded structures, and the mechanization of welding processes. He supervised the development of automatic submerged arc welding.

(1870–1953)

https://en.wikipedia.org/wiki/Evgeny_Paton

Sergei Korolev, a Soviet rocket engineer who played a central role in the Space Race of the 1950s and 60s. He was the Senior engineer in the development of the R-7 Rocket, launched the first human, Yuri Gagarin, into space.

(1907 – 1966)

[https://kpi.ua/ru/korolev]

Global challenges

In 2015, the United Nations set out a new agenda for 2030 with 17 Sustainable Development Goals (SDGs) to guide us into a better future. These goals address poverty, quality education, and climate action, among other big challenges. While these goals are not legally binding, they reflect a global consensus and a universal framework that is relevant to both global and local needs.
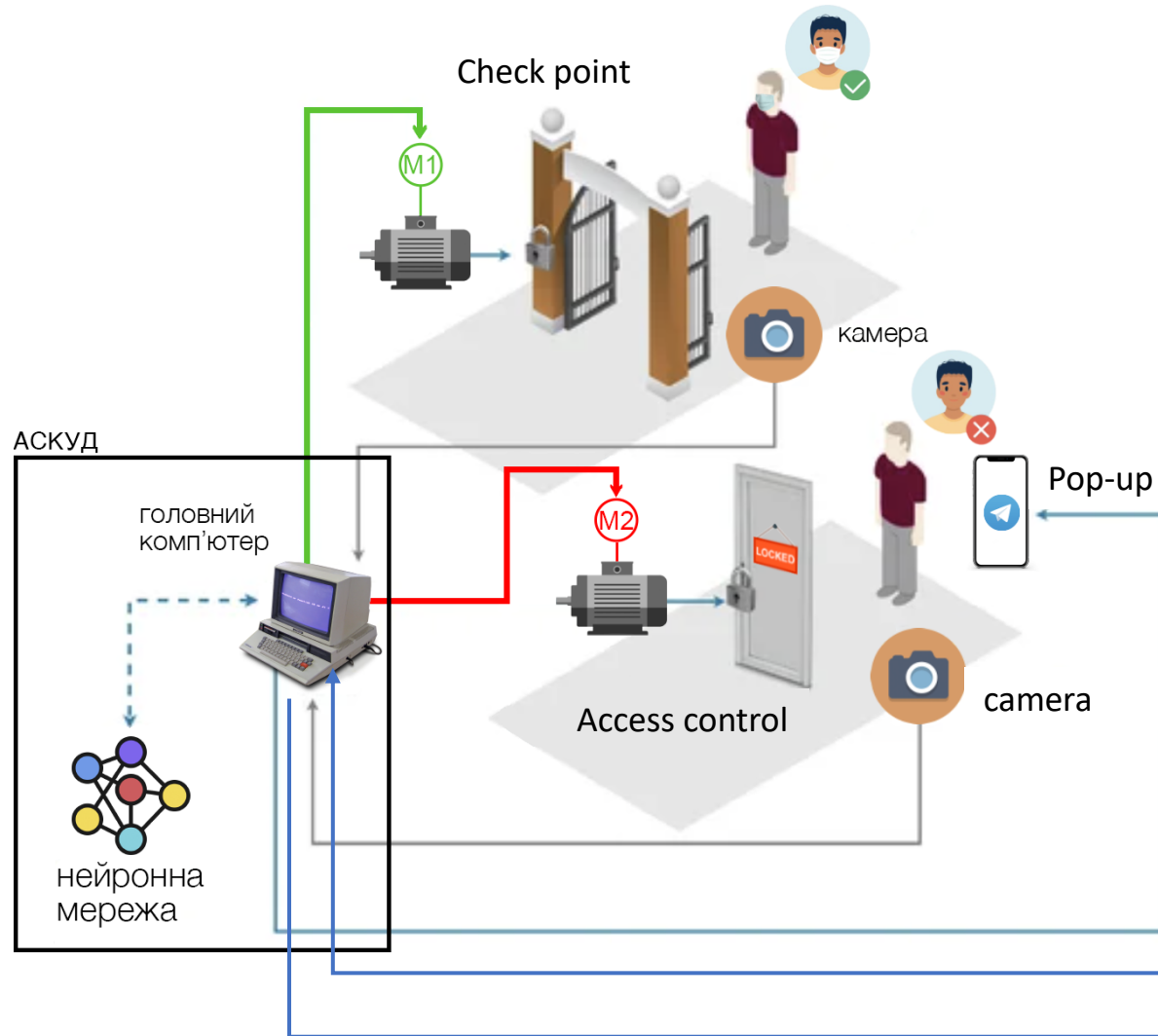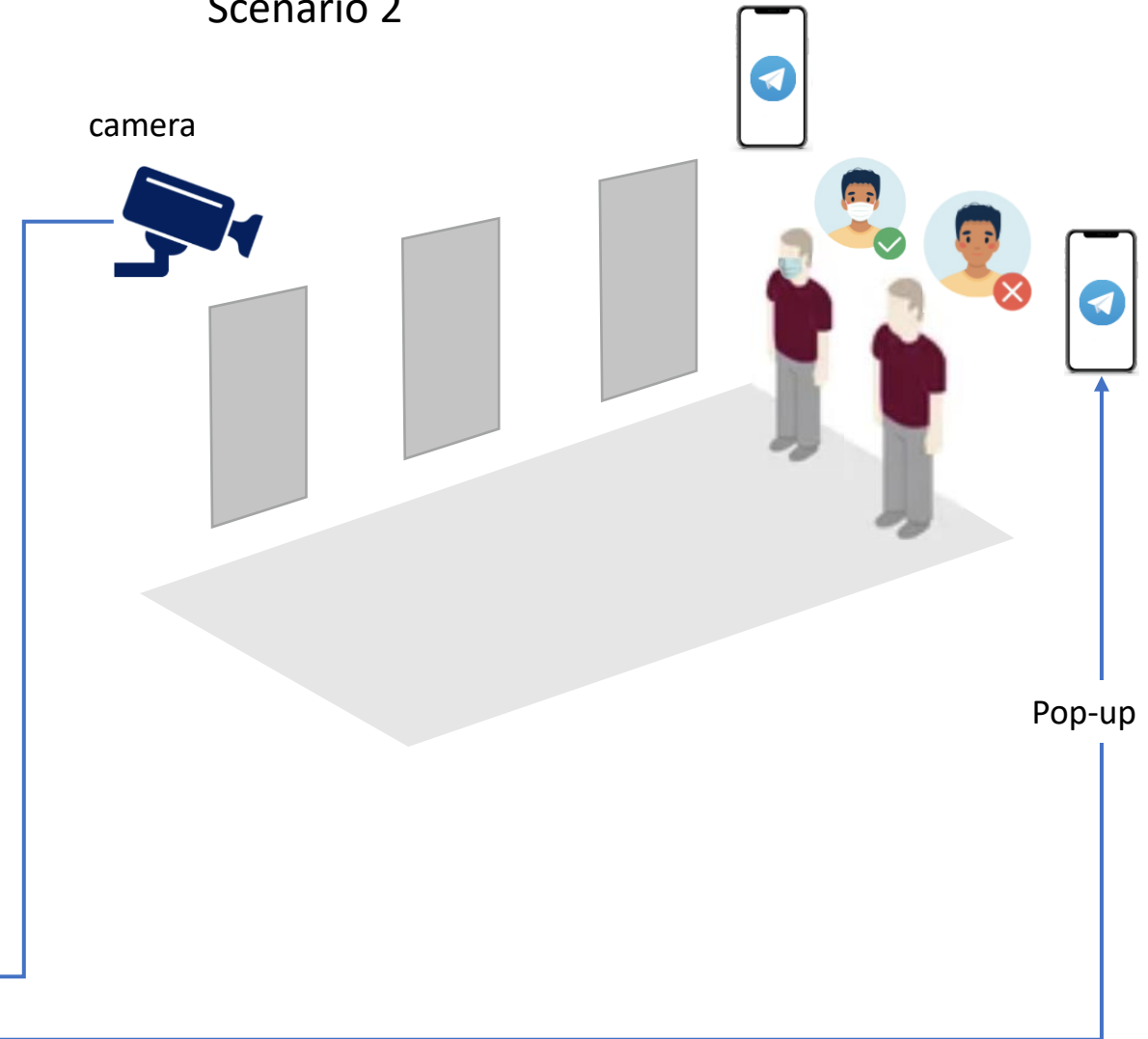
Global challenges

COVID-19, etc.

War in Ukraine

Industrial innovation
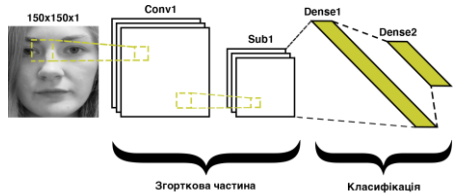
CovSecurity

Scenario 1

Check point
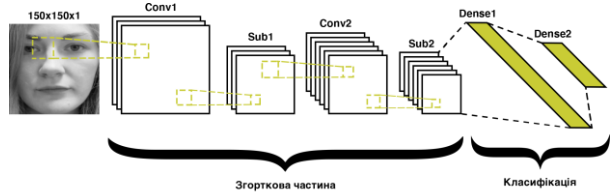
камера

АСКУД

головний комп'ютер

Pop-up

Access control

camera

нейронна мережа

Scenario 2

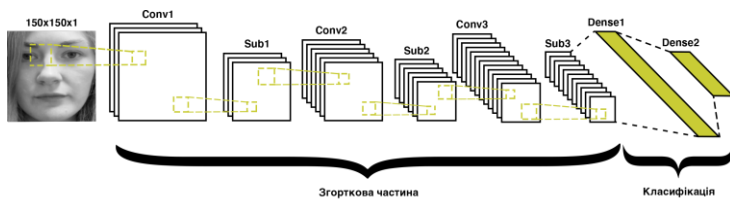camera

Pop-up

CovSecurity

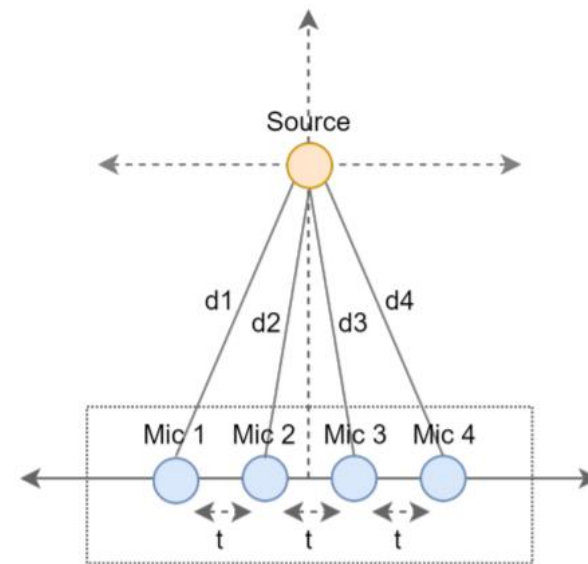|	Назва	Kernel size	Number of filters	Розмір ядра підвибірки	Batch size	Epochs	Accuracy	Loss	Val. accuracy	Val. loss	Тестова точність
CNN1	CNN1_1	(5; 5)	16	(2; 2)	32	10	0,9837	0,0517	0,8519	0,5234	0,7438
	CNN1_2	(5; 5)	32	(2; 2)	32	10	0,9861	0,0458	0,6445	0,8438	0,7028
	CNN1_3	(5; 5)	64	(2; 2)	32	10	0,9888	0,0378	0,8429	0,6616	0,6628
CNN2	CNN2_1	(5; 5)	{16; 16}	(2; 2)	32	10	0,9782	0,0624	0,89	0,4211	0,8238
	CNN2_2	(5; 5)	{32; 32}	(2; 2)	32	10	0,9787	0,0655	0,8957	0,3735	0,7799
	CNN2_3	(5; 5)	{64; 64}	(2; 2)	32	10	0,9629	0,101	0,87	0,4084	0,7771
	CNN2_4	(5; 5)	{128; 128}	(2; 2)	32	10	0,9676	0,98	0,8924	0,4196	0,8057
	CNN2_5	(5; 5)	{32; 64}	(2; 2)	32	10	0,9823	0,0536	0,8967	0,431	0,7923
	CNN2_6	(5; 5)	{64; 128}	(2; 2)	32	10	0,9775	0,0654	0,9048	0,3694	0,8047
CNN3	CNN3_1	(5; 5)	{32; 32; 32}	(2; 2)	32	10	0,9643	0,0965	0,9176	0,2686	0,8257
	CNN3_2	(5; 5)	{64; 64; 64}	(2; 2)	32	10	0,9624	0,1071	0,9119	0,29	0,8371
	CNN3_3	(5; 5)	{128; 128; 128}	(2; 2)	32	10	0,9605	0,1139	0,9262	0,2208	0,838
	CNN3_4	(5; 5)	{16; 32; 64}	(2; 2)	32	10	0,9674	0,0956	0,9024	0,3196	0,8342
	CNN3_5	(5; 5)	{32; 64; 128}	(2; 2)	32	10	0,9743	0,0773	0,9257	0,2752	0,8295
	CNN3_6	(5; 5)	{16; 16; 16}	(2; 2)	32	10	0,953	0,1257	0,9252	0,2082	0,8695

CovSecurity

- **Total training set – 10500 photos**
- **Total photos per person – 20 + augmented**
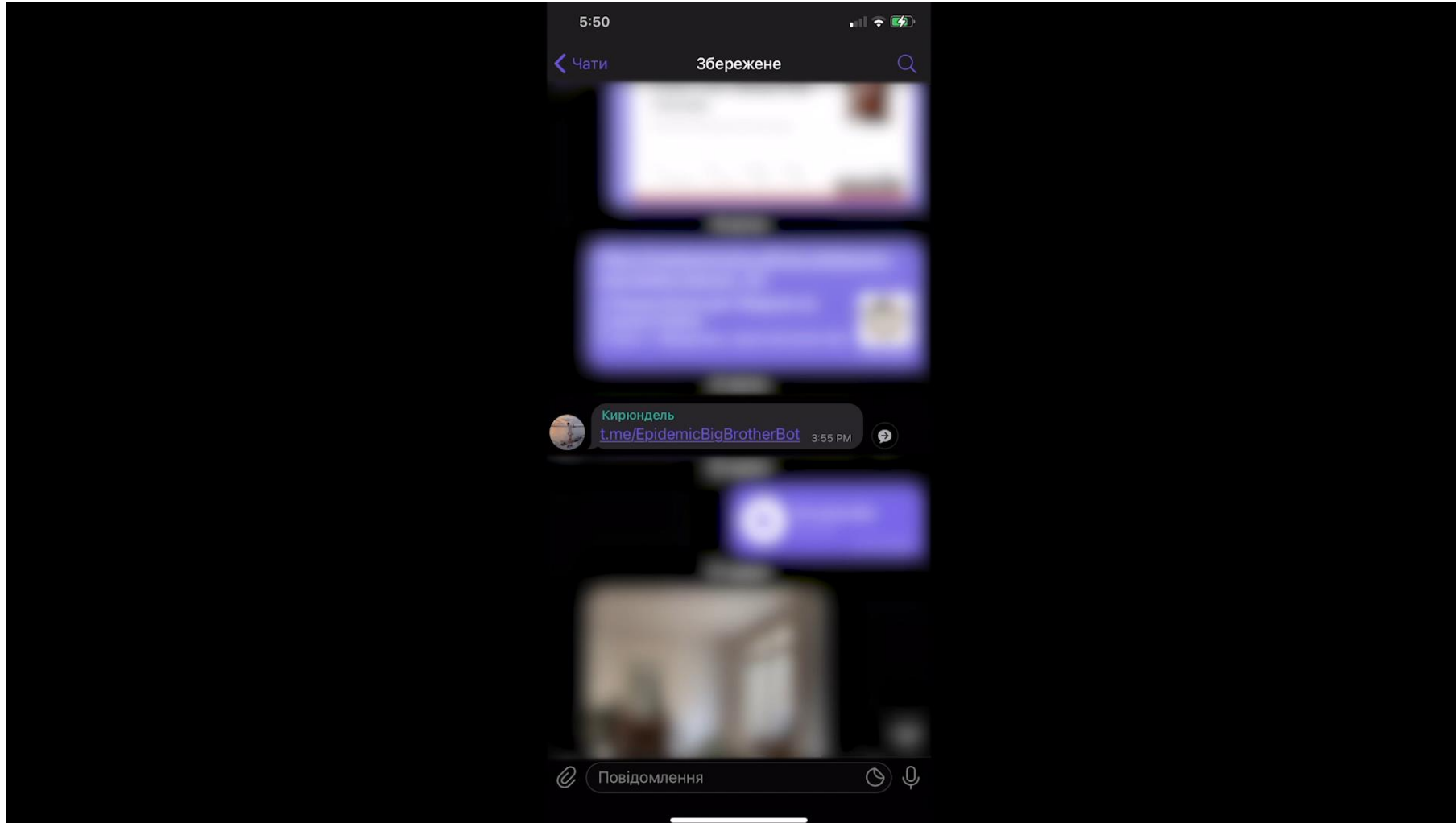
Sound identification system for domestic actions recognition
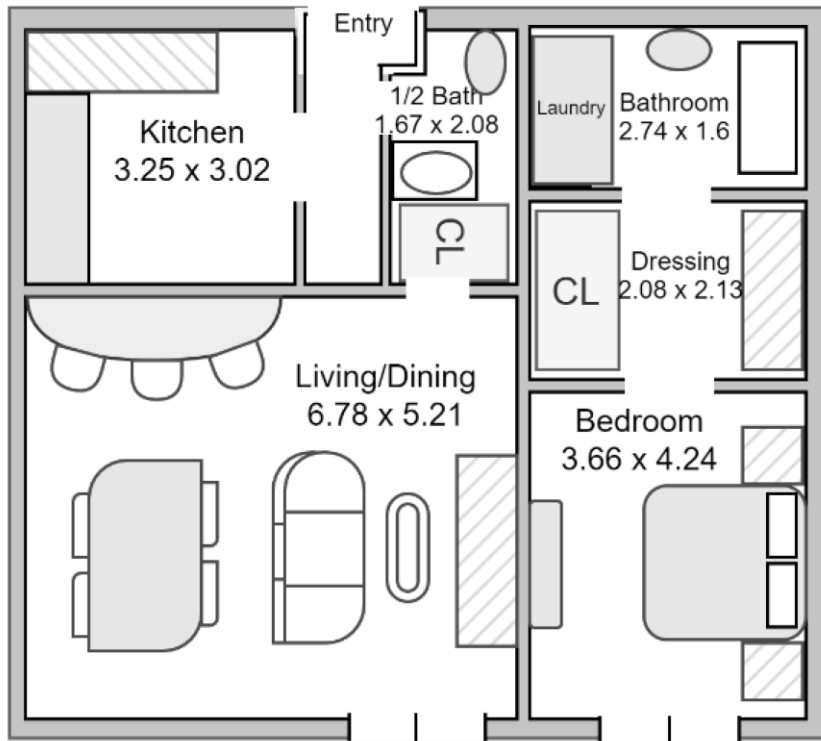
Such task become extremely important during the pandemic when to prevent Healthcare system overloading is better to predict hazards development and call for ambulance before the accident happens

["Hebrew SeniorLife." https://www.hebrewseniorlife.org/newbridge/typesresidences/independentliving/independent-living-apartments]

[A. Copiaco, C. Ritz, N. Abdulaziz, and S. Fasciani, "A Study of Features and Deep Neural Network Architectures and HyperParameters for Domestic Audio Classification," Appl. Sci., vol. 11, no. 11, p. 4880, May 2021, doi: 10.3390/app11114880.]

[Sazonov, A., Lipnickas, A., Augustauskas, R., etc. Development of Sound Identification System for Domestic Actions Recognition, *IDAACS 2021*, 2021, 2, pp. 714–719]

# Sound identification system for domestic actions recognition

The aim of the research was to improve accuracy of sounds recognition. For this purpose we have offered the following approach:

```
import required packages
        compute mel spectrogram by use of librosa;
for each spectrogram do:
        - compute the natural logarithm of mels element-wise;
        - scale up to fit inside 8-bit range;
        - put low frequencies at the bottom in the image;
        - invert image;
        - save image obtained as PNG.
end
```

[Sazonov, A., Lipnickas, A., Augustauskas, R., etc. Development of Sound Identification System for Domestic Actions Recognition, *IDAACS 2021*, 2021, 2, pp. 714–719]
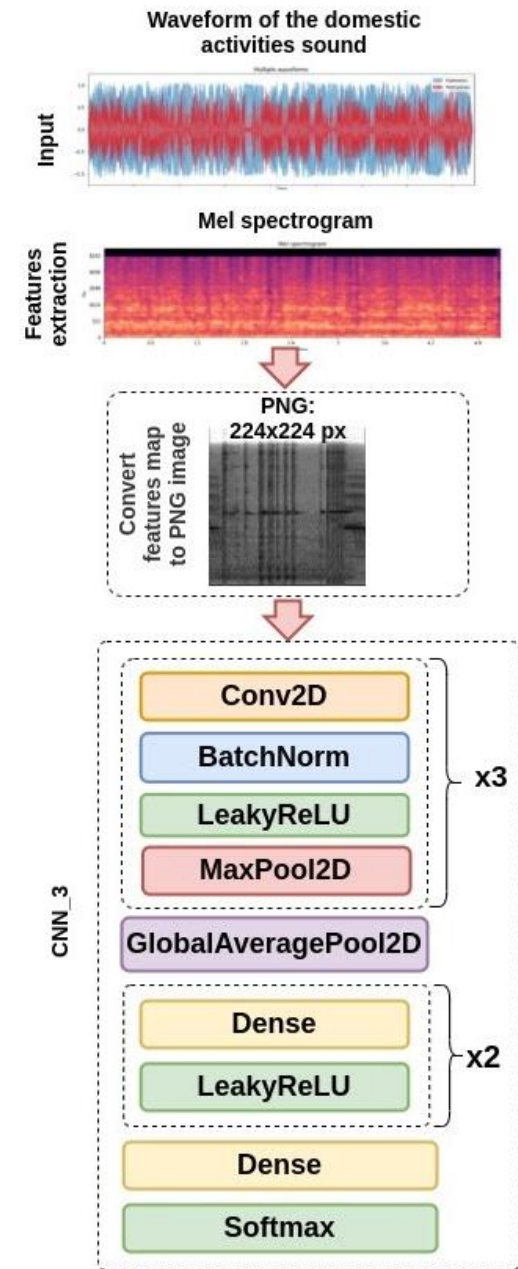
Sound identification system for domestic actions recognition

Dataset DASEE contains more than 110000 files which are categorized into 11 classes.
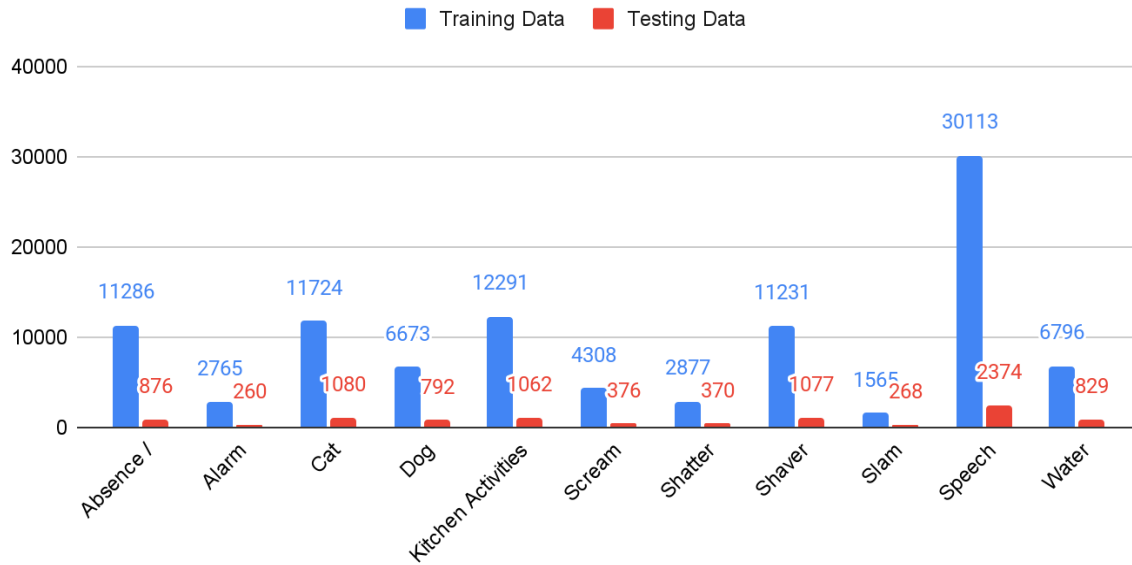
Classification mistakes depending on the apartments room

	Number of mistakes	In total data	%
Dressing	1	1142	0.09
Living	123	1872	6.57
Bath	169	2564	6.59
Bedroom	73	2724	2.68
Kitchen	194	1062	18.27

The classification performance accuracy

	Crisp	Smooth	CW	SW
Mean accuracy, %	92.20	92.33	91.25	**92.60**
Std of accuracy	0.31	0.70	1.31	**0.30**

The Dice (F1) score comparison of acoustic sound classes depending on training strategy

	Crisp	Smooth	CW	SW
Absence	100.00	100.00	100.00	100.00
Alarm	83.40	87.60	81.20	**88.60**
Kitchen	87.20	**87.60**	85.80	86.20
Scream	88.60	88.20	**90.20**	89.00
Shatter	88.20	88.80	87.20	**89.60**
Shaver	90.40	**90.60**	86.40	89.80
Slam	65.40	68.40	69.00	**73.20**
Speech	**99.40**	98.80	99.00	98.80
Water	**88.60**	86.80	85.60	86.60
Cat	91.20	90.80	**91.60**	91.20
Dog	92.00	93.00	92.40	**94.20**
Std of interclass result	9.14	8.20	8.50	**7.12**

[A. Copiaco, C. Ritz, N. Abdulaziz, and S. Fasciani, "A Study of Features and Deep Neural Network Architectures and HyperParameters for Domestic Audio Classification," Appl. Sci., vol. 11, no. 11, p. 4880, May 2021, doi: 10.3390/app1114880.]

[Sazonov, A., Lipnickas, A., Augustauskas, R., etc. Development of Sound Identification System for Domestic Actions Recognition, *IDAACS 2021*, 2021, 2, pp. 714–719]

REB – Walking REscue robot. ONGOING
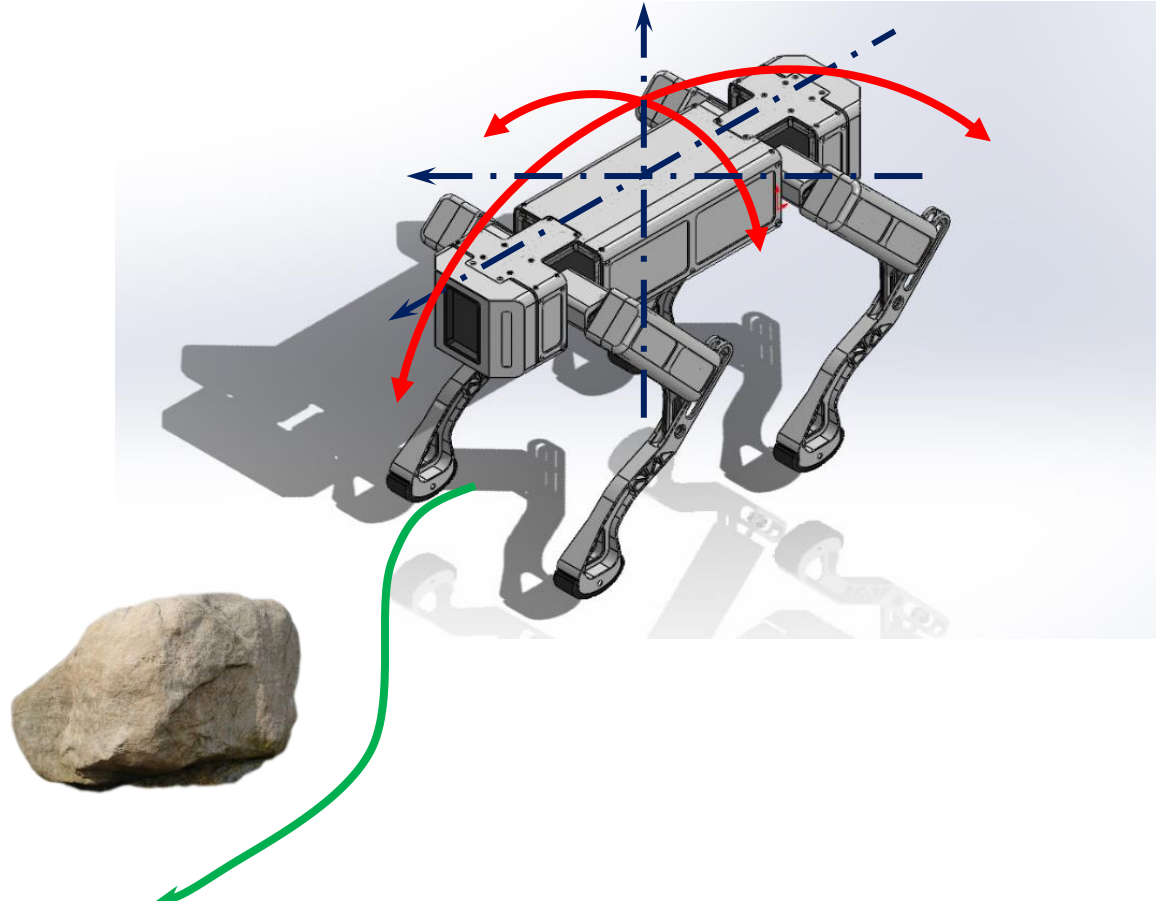
REB – Walking REscue robot. ONGOING

[https://kyiv.comments.ua/news/society/developments/9080-v-borodyanke-nachali-razbirat-zavaly-strashno-dazhe-spasatelyam-foto-video.html]

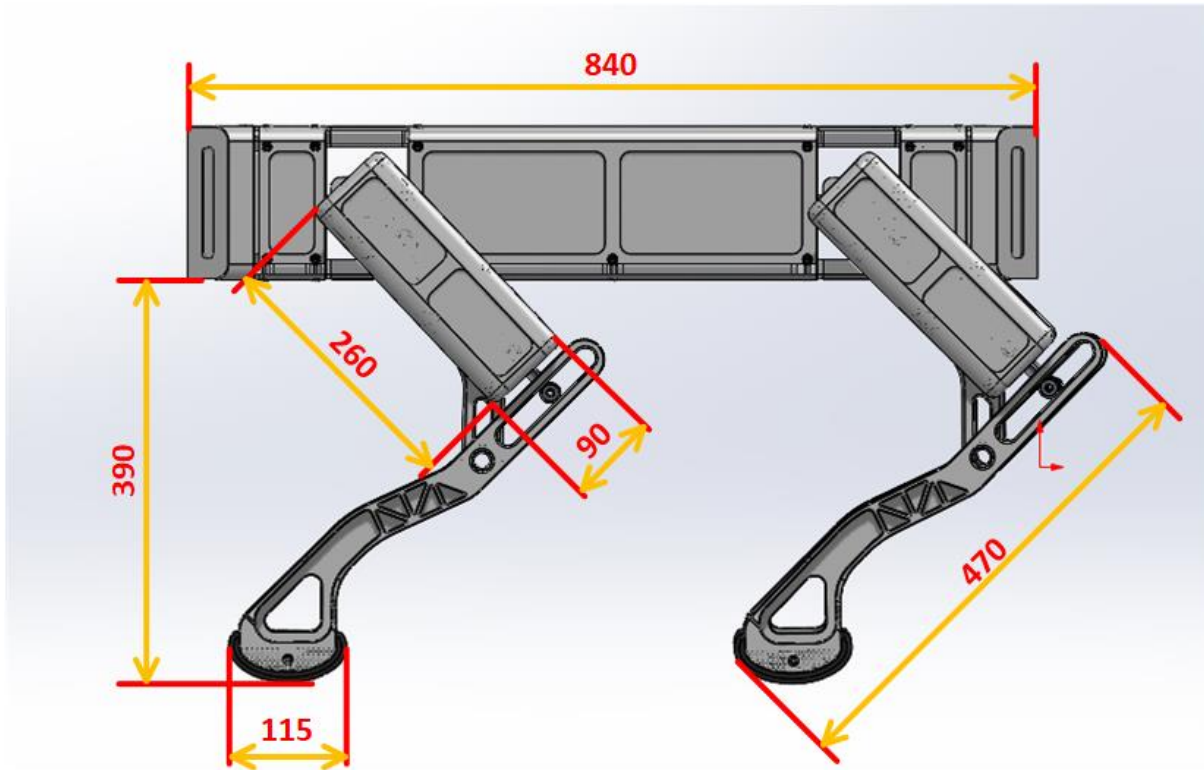[https://lb.ua/society/2022/03/04/507940_zhitomiri_vorog_v dariv_shkoli.html]

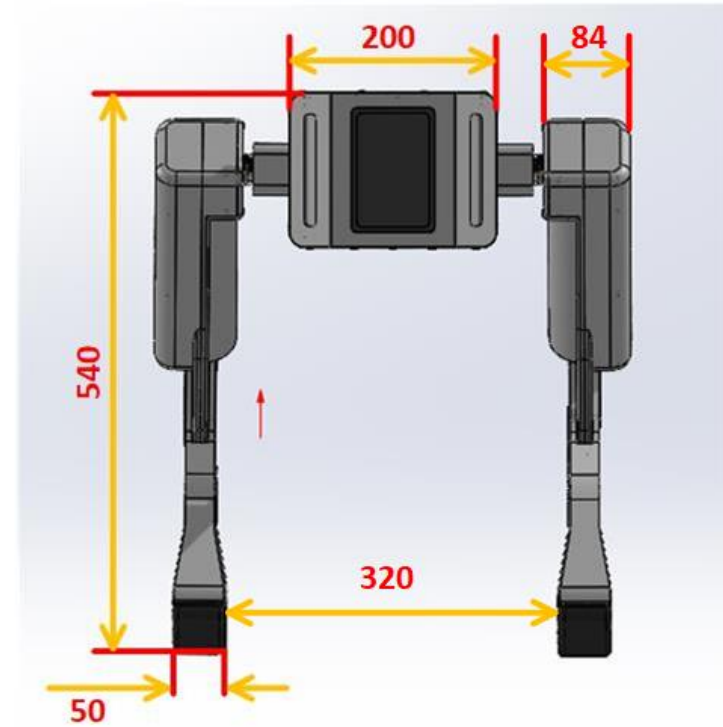# REB – Walking REscue robot. ONGOING

Problems to be solved:

- Robot's top platform stability which performs injured person transporting

- Obstacles detection considering complex and rocky terrain

- Path planning and correction

REB – Walking REscue robot. ONGOING

Robot design

Payload: 150 kg

REB – Walking REscue robot. ONGOING

Static modeling
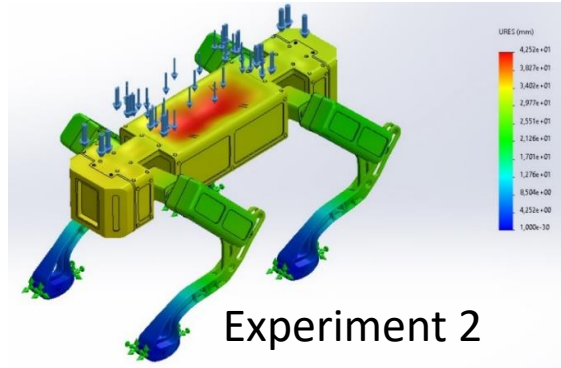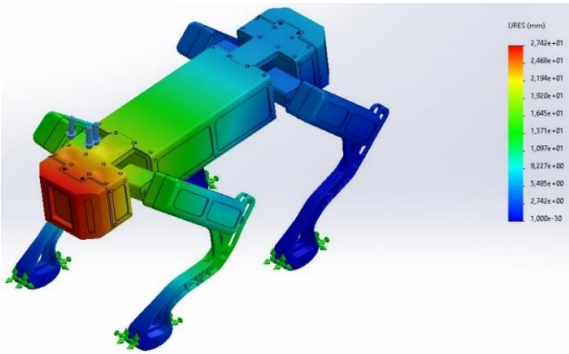
Experiment 1
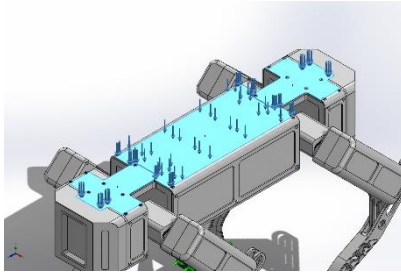
Experiment 2
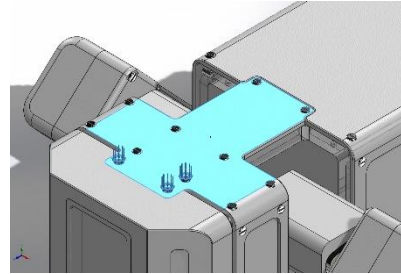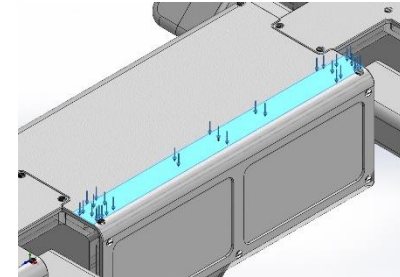
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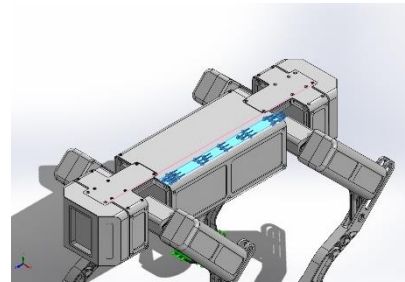
Experiment 4
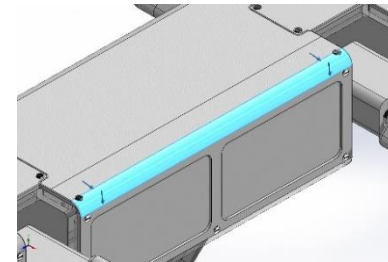
Experiment 5

Load varies from 10 to 200 kg

REB – Walking REscue robot. ONGOING
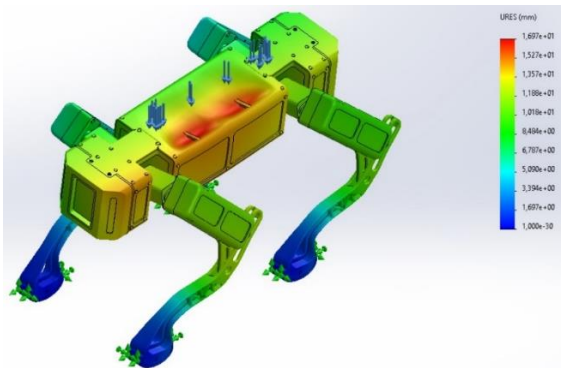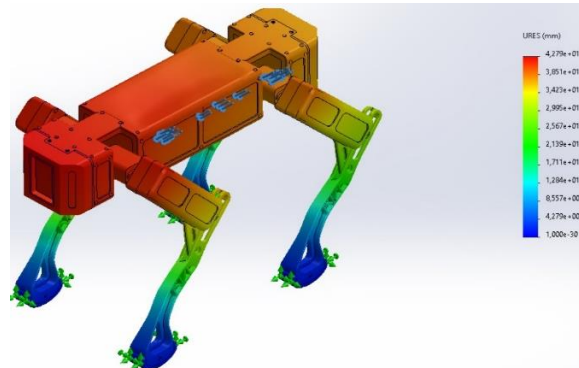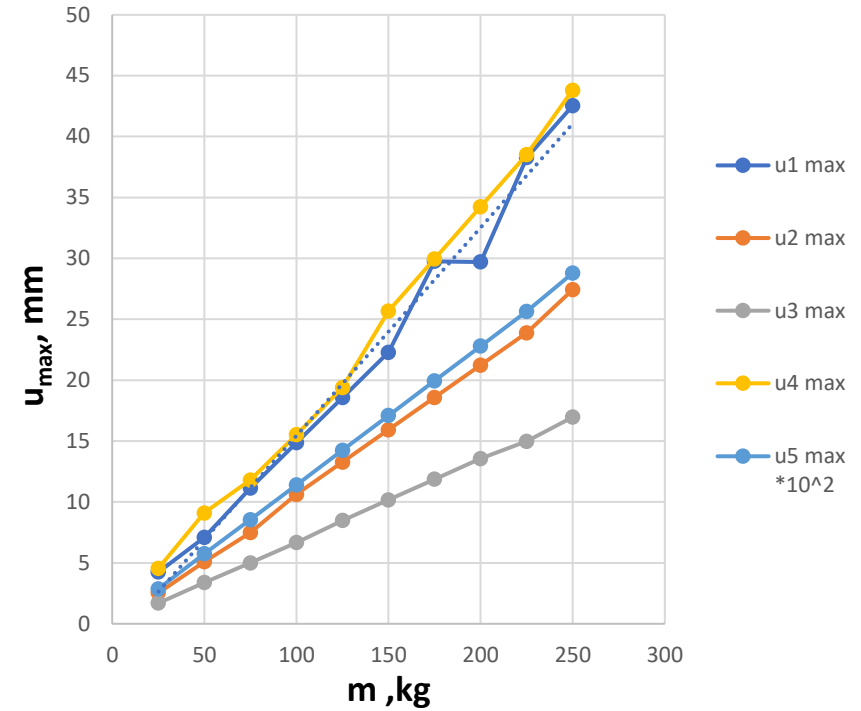
Experiment 1

Displacement gradient

Experiment 4

Experiment 2

Experiment 5

Experiment 3

Maximal displacement depends on the load

REB – Walking REscue robot. ONGOING
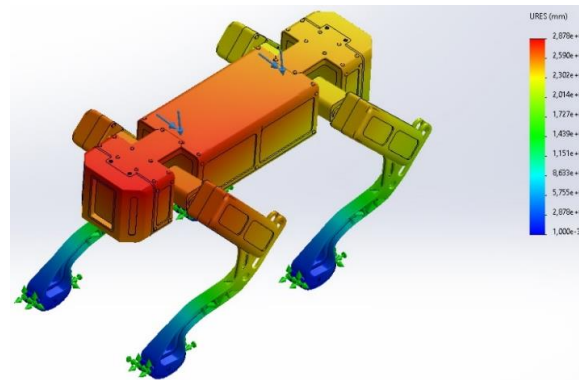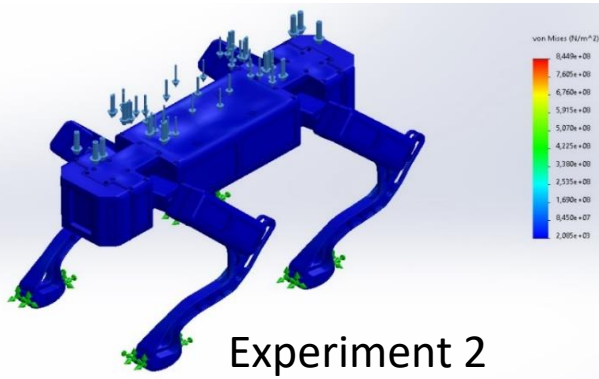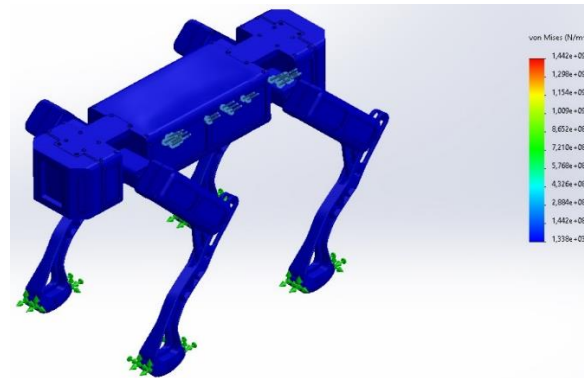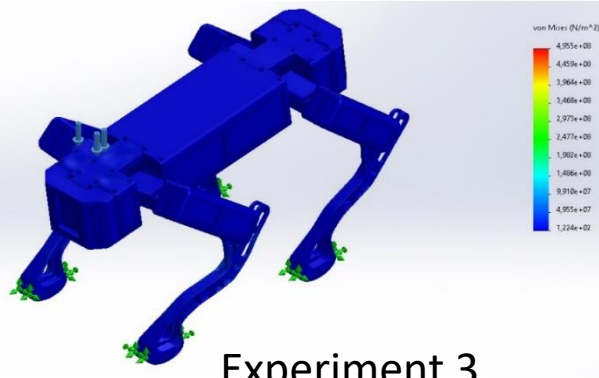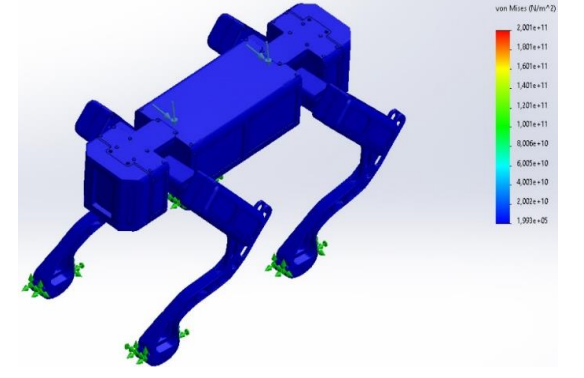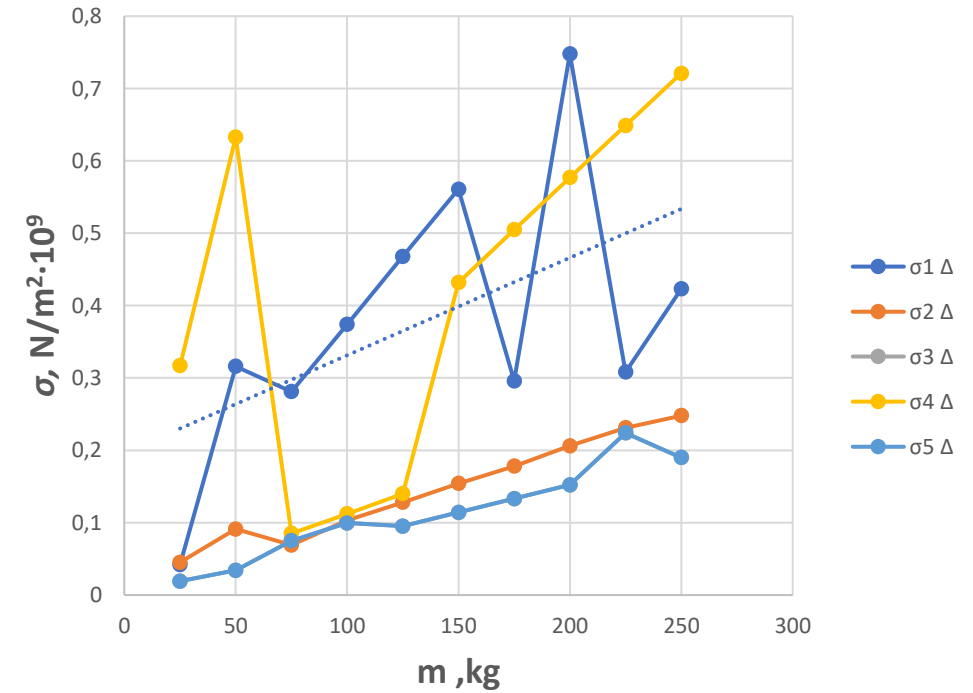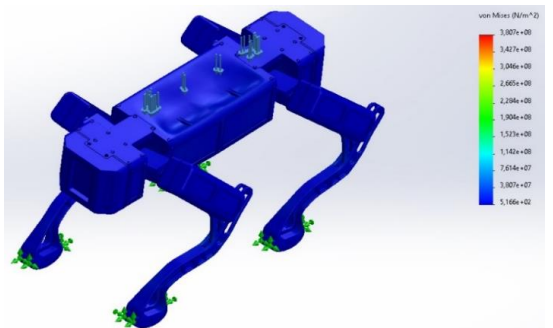
Experiment 1

Experiment 2

Experiment 3

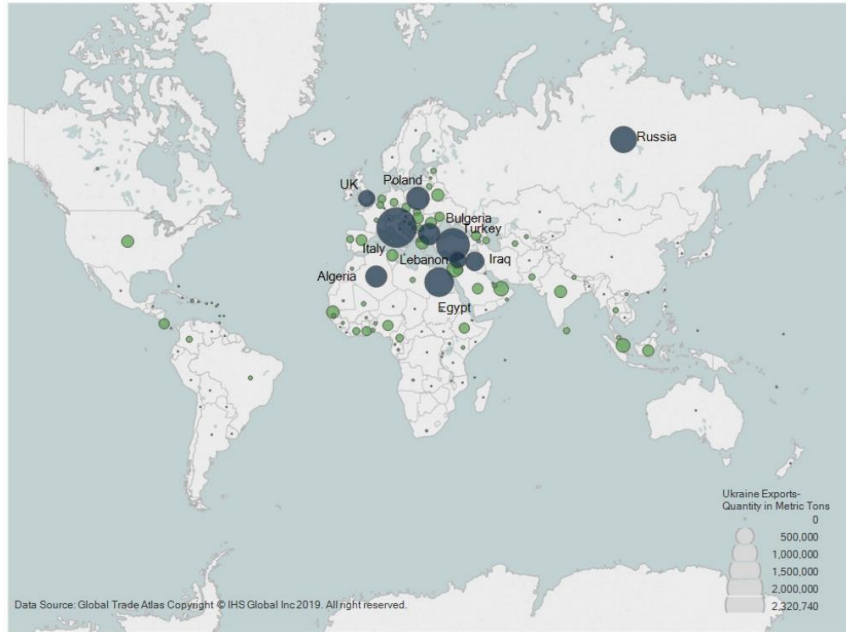Experiment 4

Experiment 5

Maximal stress depends on the load

AI for Definition of Chemical Composition of Metal-Containing Substances

In 2017, Ukraine was the world's **eleventh** largest steel exporter. In 2018, Ukraine exported 15.1 million metric tons of steel.
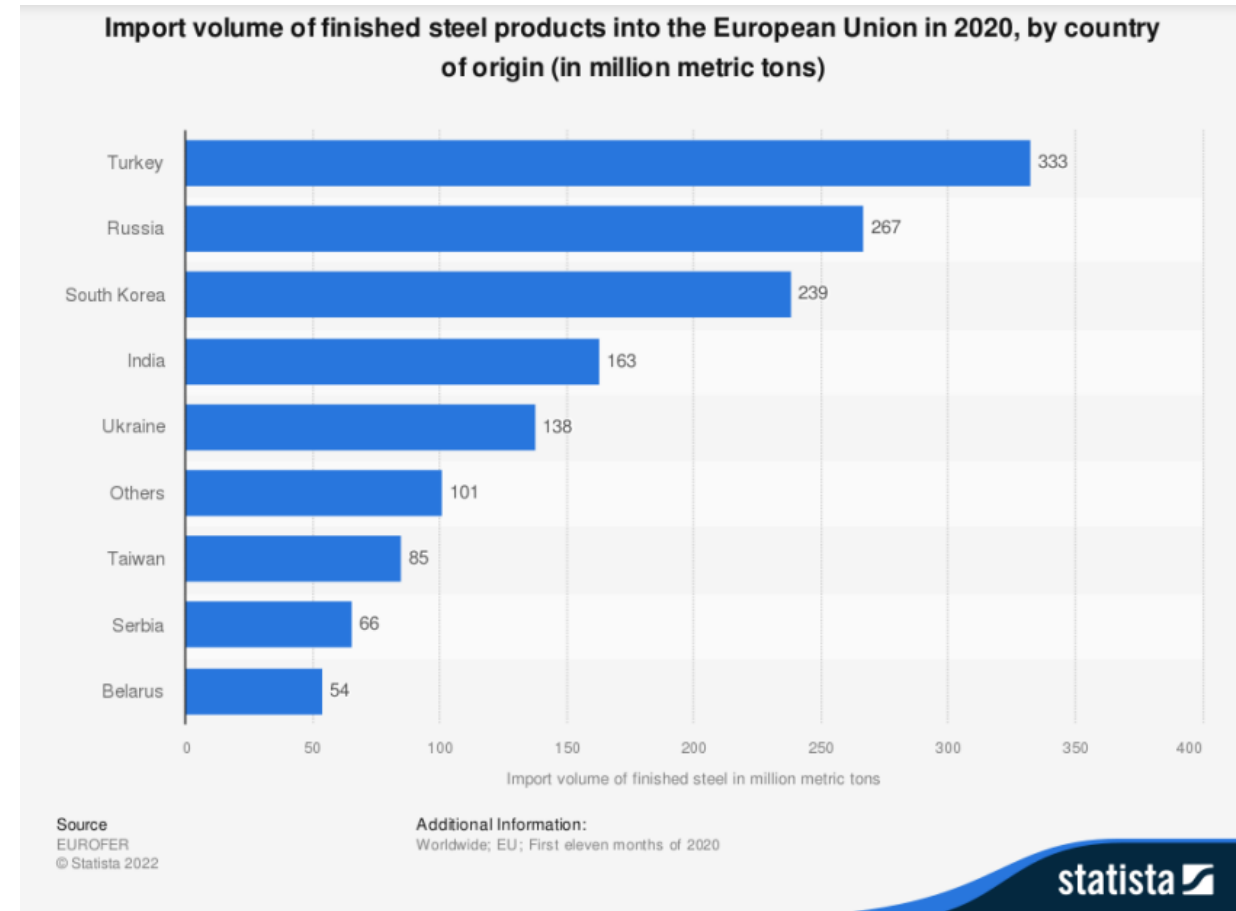
In 2020 Ukraine exported **136M** tons of steel products to EU and took 5th place

Ukraine's Exports of Steel Mill Products-2018 (Top Ten in Blue)

Data Source: Global Trade Atlas Copyright © IHS Global Inc 2019. All right reserved.

Ukraine Exports-
Quantity in Metric Tons
0
500,000
1,000,000
1,500,000
2,000,000
2,320,740

[https://legacy.trade.gov/steel/countries/pdfs/2018/annual/exports-ukraine.pdf]

Chemical composition of metal-containing substances is extremely important and specific task of modern metallurgical, machine-building, processing, etc. productions. The relevance of this task is caused by ever-increasing requirements of global industrial market and international product quality standards.

Import volume of finished steel products into the European Union in 2020, by country of origin (in million metric tons)

Country	Value
Turkey	333
Russia	267
South Korea	239
India	163
Ukraine	138
Others	101
Taiwan	85
Serbia	66
Belarus	54

Import volume of finished steel in million metric tons

Source
EUROFER
© Statista 2022

Additional Information:
Worldwide; EU; First eleven months of 2020

statista

[https://www.statista.com/statistics/1129472/leading-exporters-of-finished-steel-to-the-eu/]

AI for Definition of Chemical Composition of Metal-Containing Substances

Existing methods and equipment

Thermo ARL - ARL 4460
Optical Emission Spectrometer
(Thermo Scientific, US)

Spectrophotometer ULAB 102
(Ulab, China)

ISKROLINE 300
('Iskroline', Russia)

[http://www.speciation.net/Database/Instruments/Thermo-ARL/ARL-4460-Optical-Emission-Spectrometer-;i1524]

[http://himstatus.com.ua/katalog/obschelaboratornoe-oborudovanie/spektrofotometry/spektrofotometr-ulab-102-325-1000nm-programmiruemyj]

**Cons:** the duration of chemical elements determination by optical emission spectrometer ARL 4460 is **up to 1 min**, poor accuracy, e.i. error of the emission spectrometer for both 'Iskroline 100' and atomic emission spectrometer 'ISKROLINE 300' varies in range 0.5 to 40%

AI for Definition of Chemical Composition of Metal-Containing Substances

Intelligent Precise Goniometric System (IPGS)
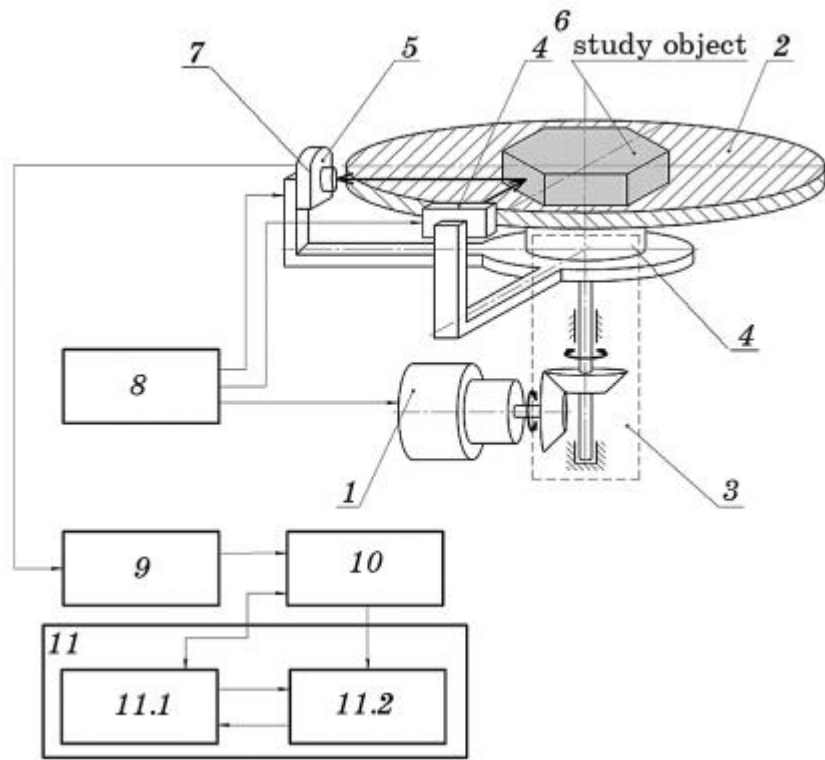
1 – drive; 2 – table; 3 – rotating device; 4 – ring laser; 5 – autocollimator; 6 – laser emitter; 7 – photosensor; 8 – power supply; 11 – PC with the installed software for chemical composition analysis (11.1 – App; 11.2 – User interface)
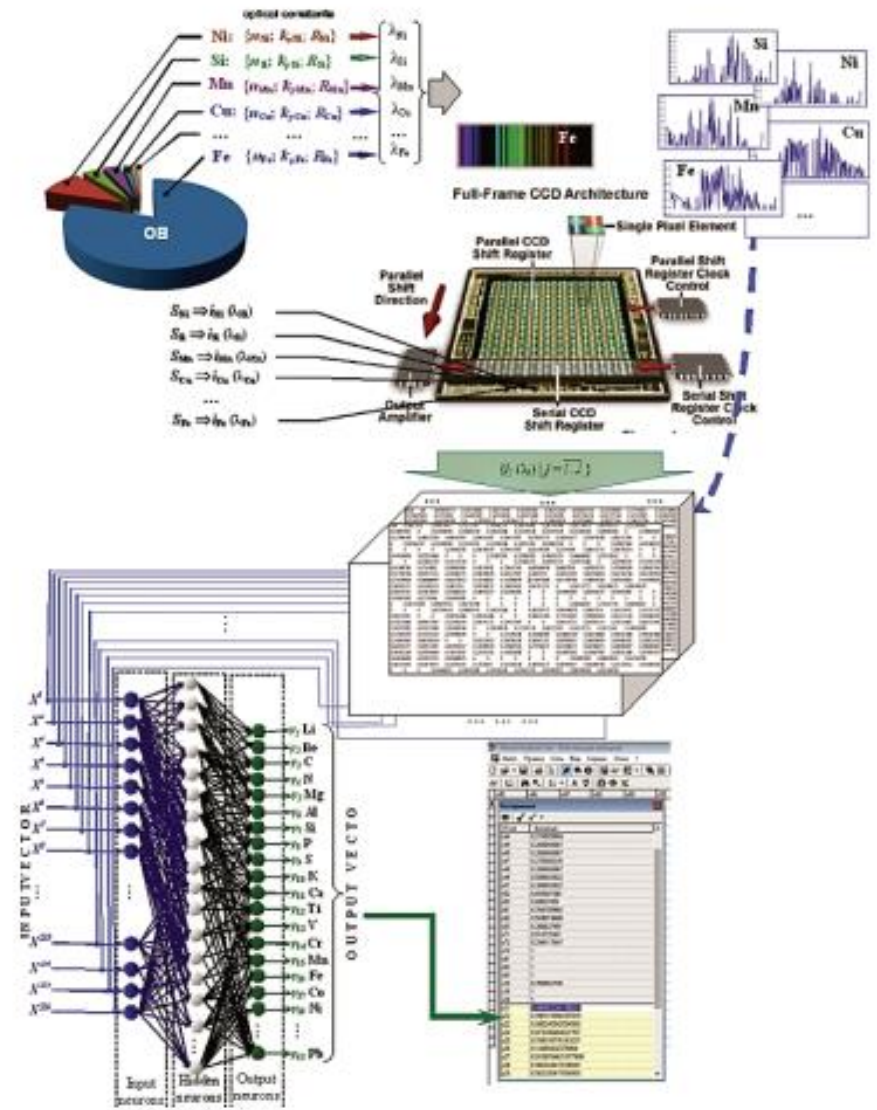
[Artificial neural network as a part of intelligent precise goniometric system for analysis of spectral distribution intensity and definition of chemical composition of metal-containing substances Cherepanska, I., Koval, Y., Bezvesilna, O., Sazonov, A., Kedrovskyi, S. Metallofizika i Noveishie Tekhnologiithis link is disabled, 2020, 42(10), pp. 1441–1454]

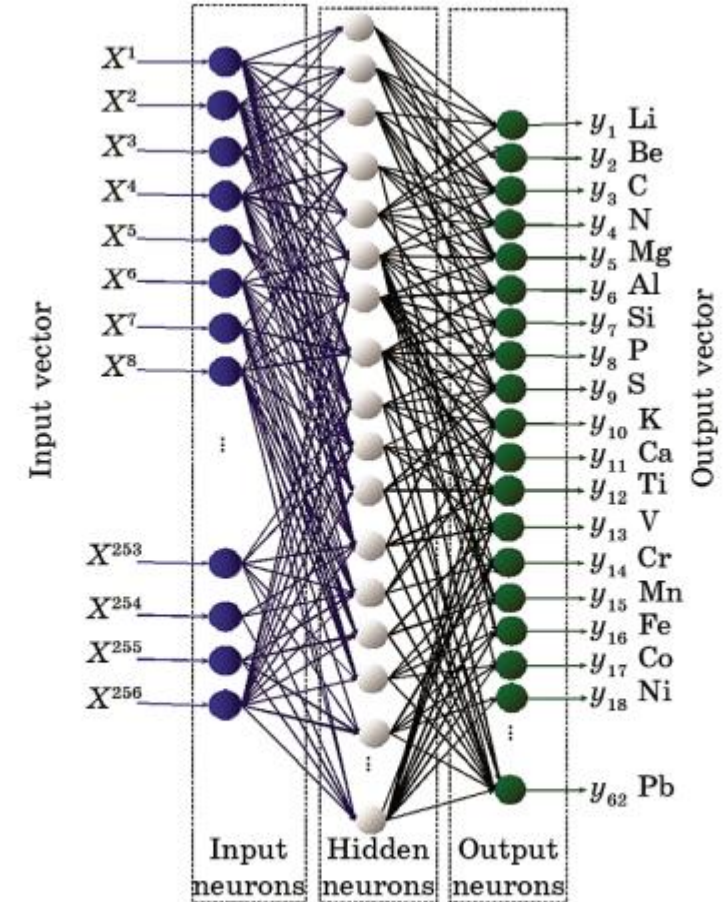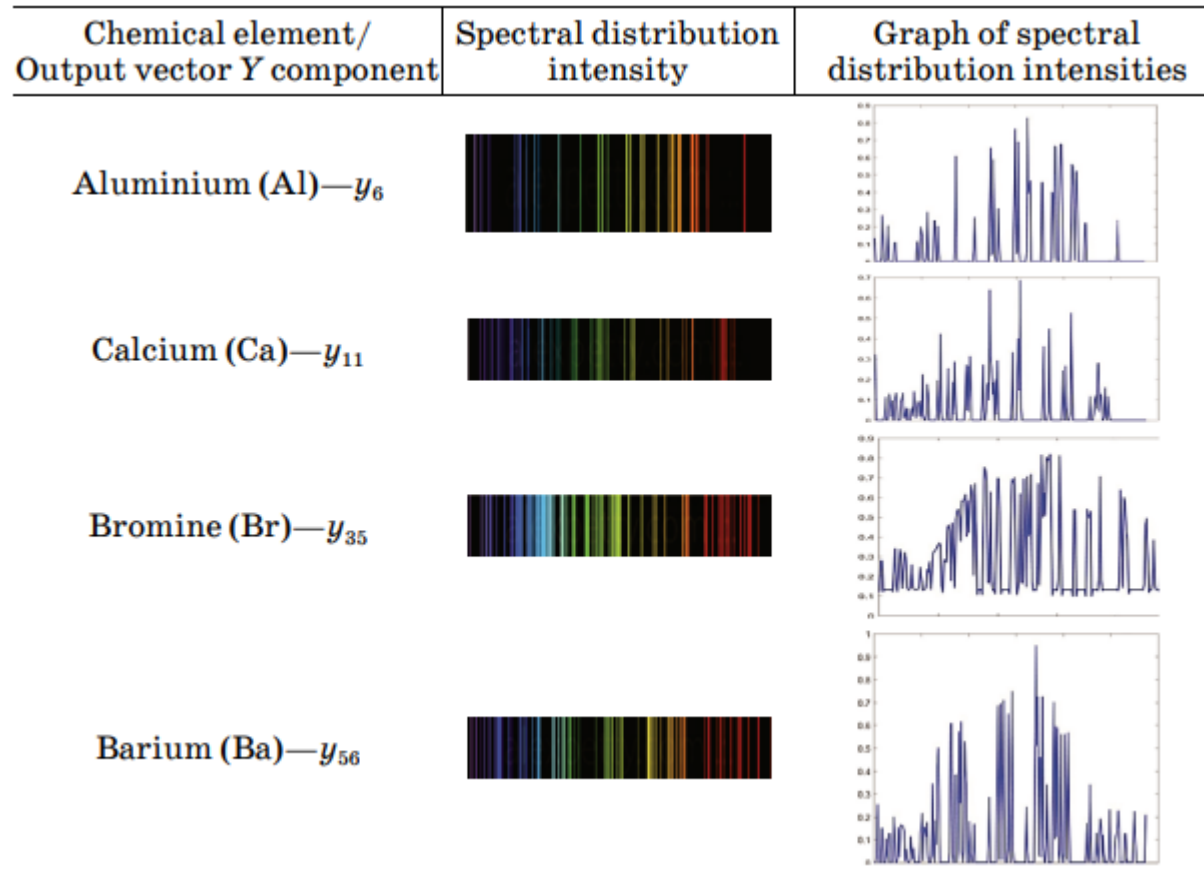# AI for Definition of Chemical Composition of Metal-Containing Substances

Fig. 1. Schematic model of the developed ANN ARoC: input neurons 256, hidden neurons 275, output neurons 62.

AI for Definition of Chemical Composition of Metal-Containing Substances

Comparative characteristics of the proposed ANN ARoC with the existing methods

Name	Accuracy	Performance	Work in real time mode	Automated data processing	Versatility (possibility of readjustment and/or increase the list of chemical elements)	Compatibility of specialized software and OS Windows
ANN ARoC	95%	Up to 2.5 s	+	+	+	+
Optical emission spectrometer ARL 4460 [3]	90%	Up to 1 min	−	+	−	−
Emission spectrometer 'Iskroline 100' [4]	60%	Up to 2 min	−	+	−	+
Atomic emission spectrometer 'ISKROLINE 300' [5]	60%	Up to 2 min	−	+	−	+
Spectrophotometer ULAB 102 [6]	85%	Up to 1 min	−	+	−	−

[Artificial neural network as a part of intelligent precise goniometric system for analysis of spectral distribution intensity and definition of chemical composition of metal-containing substances Cherepanska, I., Koval, Y., Bezvesilna, O., Sazonov, A., Kedrovskyi, S. Metallofizika i Noveishie Tekhnologiithis link is disabled, 2020, 42(10), pp. 1441–1454]

Thank you for your attention

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