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TECHNOLOGY OF OBJECTS RECOGNITION BY DRONES WITH HUMANITARIAN MEDICAL CARGO

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Abstract*—The problems of objects recognition by drones (UAVs) were observed, the general analysis of these problems was done. The central purposes of the work were outlined, as well as the set of tasks for these problems solutions. In process of the work the observation of prototypes and analogs – the versions of previously constructed UAV modules with images recognition abilities were done for providing medical assistance in extreme conditions. The aim of present work was to develop mechanisms and possibilities of image recognition by UAVs for medical purposes, and to clarify the possibility of humanitarian cargo transportation by UAVs to programmatically defined object or person. To do this the experience of prototypes creation, and their analysis were taken into account. The algorithms of necessary operations and suitable software were developed to automate processes. Developed software was designed basing on a face recognition technology convolutional neural network. All necessary information concerning all stages of the work was described profoundly. Originally developed humanitarian UAV was constructed with various modules (for diagnosing a person's health state, providing patient with appropriate medical care, others); and module for images recognition in point of destination was one of them. The sample of created algorithm and few fragments of novel program supply were given in present article. Developed UAV can be used repeatedly for different tasks solutions: monitoring of area pollution (chemical or other); medical equipment and first aid means can be parachuted over the point of location of potentially injured person, etc. In both cases images recognition functions are desirably for the drone. Preliminary data concerning successful application of work results, some given practical recommendations were described.*

Keywords—Modeling; unmanned aerial vehicle; drone; objects recognition; functional module; construction; medical cargo.

I. INTRODUCTION

Development and creation of unmanned aerial vehicle (UAV, drone) or complicated aircraft complexes from several UAVs aimed at providing of medical care in extreme conditions is really important task for today. To accelerate the delivery of blood samples, obtaining transplants, medicines, vaccines and medical equipment necessary for doctors, it is important to carry out the development of modern unmanned aerial systems with containers for transporting such medical humanitarian cargo [1] – [8]. We have already published the preliminary results of this work, Fig. 1, [9], [10].

The large-scale contemporary progress of UAVs technologies has caused consequent progressive changes also in related areas of human activities in Ukraine and in the world. Targeted delivery of medical, biological, and other humanitarian cargo by UAVs is important also in peacetime, in territories where military operations are not taking place.

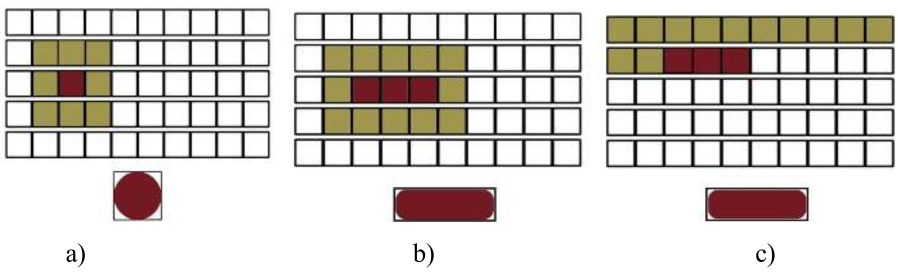

Fig. 1. Three examples of visual representation of the simplest figures by 2D screen in technical device: (a) the static image: a dot with blurry, fuzzy edges of the image; (b) the static image: a line segment with blurry, fuzzy edges of the image; (c) the moving object: a line segment with straight, clearly defined edges [9]

Contemporary Ukraine is characterized by large spaces, sometimes with distant and hard-to-reach locations – and population there need such distant services. Among them there are, for example, the western slopes of the Chornohirsky Range in the Carpathians, the marshy-lake region of Stokhid in the Manevich region, and many others. However, the peoples' life at these territories and their economic activities are objectively associated with number of difficulties, which requires the delivery of humanitarian cargo using UAVs. Modern developed image recognition technologies can guarantee the targeted delivery of cargo there with high accuracy.

II. Problem Statement

In our previous articles, prototypes and analogues of original developed drones were described [9], [10]; the main components of the work done were highlighted: some versions of the UAVs structures, such as: attaching a container for transporting humanitarian cargo, the structure of the container itself, and certain software for the UAV to perform certain medical assistance tasks in extreme conditions [4] – [8]. Such inventions were related often to aviation systems and complexes for providing rescue operations, which were used to save people during fires in high-rise buildings, earthquake zones, man-made accidents and disasters. More specifically, such a UAV system can be used to rescue people injured in fires, smoke and harmful or dangerous substances leaks in residential, industrial, and other buildings.

If we speak about the aviation system for providing rescue operations, then it contains a manned vertical take-off and landing aircraft, and can also be formed by a group of vertical take-off and landing aircraft with the possibility of their hovering. The authors of such developments emphasize that the aviation system for providing rescue operations should include a manned aircraft with tunnel propellers and one, two, three (or more) unmanned "flying platforms", which are, in essence, UAVs with certain rescue equipment attached to each of them. At the same time, each of the "flying platforms" should be equipped with homing equipment, mooring and self-fixing to the emergency object with devices for disconnecting from the delivered rescue equipment and the ability to leave the disaster zone. Also, the manned aircraft, as a carrier of "flying platforms", should be equipped with means of detecting and marking the intended places of self-fixation of "flying platforms" and provided with devices for their fastening, regular and emergency disconnection from its board, as well as provided with equipment for controlling and monitoring the operation of the entire aviation system in manual and automated modes [10], [11]. The authors have the experience in the solution of such tasks in bionics [9] – [12], and in linked spheres for environment monitoring [11], [13], [14]. But the development of object recognition abilities in drones using specialized systems raises the reliability of UAVs functioning to qualitatively new level. Development of such highly qualified, specific novelties forms new abilities for economy and defence in Ukraine.

The aim of present work was to develop mechanisms and possibilities of image recognition by UAVs for medical purposes, and to clarify the possibility of humanitarian cargo transportation by UAVs to programmatically defined object or person. To do this the analysis of prototypes – versions of previously developed UAV's modules for medical support in extreme conditions were taken into account.

III. Problem Solution

A. Transporting of medical container to a specific object or person: object recognition

Object recognition (including faces recognition), is one of today's advanced technologies, embedded in all kinds of applications, from airport security kiosks to social media engines.

Let's analyse the set of principles for objects recognition by drones systems (including faces recognition). Modern objects (faces) recognition clearly depends on specific technologies and algorithms that were developed in the era of machine learning and artificial intelligence in the early 21st century. In particular, most advanced face recognition programs have a type of neural network called a convolutional neural network (CNN). The system uses convolutions, as well as other algorithms that work in sequential stages, to perform complex image analysis and even identify people, animals, objects, or settings through advanced analysis.

Person's recognition systems (as well as face recognition) work by forming representation of a person based on deep learning (using CNN) and matching representations. Each algorithm in the neural layers processes the collected information and applies a nonlinear transformation to its input to produce output data with a reasonably accurate level of accuracy. The data must pass through several layers of processing, each of which uses a convolution kernel to extract the most important features of the data. One of the main characteristic of a CNN is studying of functions. First, the person must be identified in the context of the image so that facial features can be analyzed. Methods such as Viola-Jones were used to decompose the image by shifting of colors and locally analyzing groups of pixels to find features such as noses, ears, eyes, etc. The same neural networks for facial recognition often use ratios such as the ratio of eyes to hairline, ears to nose, or other standard facial ratios that can help with face recognition. A machine learning program can use the uniqueness of each face to learn how to identify a person using existing data and extrapolation principles. The image is then compared to all known faces to uniquely identify such person.

Other aspects of such researches include maximum pooling, where a machine learning program simply keeps the most important information while discarding unnecessary data, and nonlinear pattern recognition algorithms such as ReLu, which is sometimes described as the "activation function" of a network. Successive rounds of convolution/ReLu/pooling create a combined effect. Techniques such as stepping and backtracking allow the program to "scan" the topography of the image to refine it.

So, with all this winning technology, a person (face) recognition technology can be surprisingly perfect at learning how to recognize a specific person's face in a crowd. Facial recognition software is used in payment processing to replace cards with faces (such as fingerprints), for access and security purposes, and to identify criminals [15].

At the same time, it is also one of the most controversial technologies, among those being used for the first time today, as it raises serious questions about security and privacy rights, as well as how these persons (facial) recognition applications can be used safely and adequately.

The software codes presented below in this article, which were written in Python using online drone programming courses [16]. They are examples of such persons (facial) recognition module that works with a camera and replaces a face detector and an object detector. In the first step of the operation, the camera, using the written software, detects the appearance of a person or object and "captures" its image. Then, two schemes of operation of the facial or object recognition module are possible: identification and verification:

a) in the *identification* mode, the "captured" face or object is compared with all images stored in functionally linked database;

b) in *verification* mode, the face of a person or a certain object located in a certain closed area is compared with photographs of persons or objects that have the right to be saved there.

B. *Module options for medical UAVs*

To provide effective first aid, it is not enough to have just a set of basic medical equipment. Preservation of human life and health sometimes requires the use of technical diagnostic tools. To solve this problem, an UAV first aid complex can be proposed, which includes a UAV with fixed modular systems of medical equipment and first aid means. In this case, the aircraft apparatus must have connectors that will provide the ability to charge its batteries from the car's power supply system and from the household power supply network. As well as complex of the modular systems of first aid means contains a voice information unit that automatically can be initiated when it touches the ground and turns off automatically: when the UAV is raised to a certain height above the ground or manually: by pressing a special button.

Some UAVs by themselves can be used too as a reception point for a primary care doctor within the framework of "Telemedicine". Telemedicine is a method of providing medical services where distance is a critical factor – and such possibilities are extremely valuable in contemporary Ukraine too. Services are provided by representatives of all medical specialties using information and communication technologies after receiving the information necessary for the diagnosis, treatment and prevention of the disease [17], [18]. UAV can be used also repeatedly, and modular systems of medical equipment and first aid supplies can be parachuted over the location of the wounded (injured) with their subsequent return when the wounded (injured) person is delivered to medical institutions. Some UAV technologies permit to organize mobile connections for providing medical care close to battle locations where normal connections are impossible [17] – [20].

C. *Development of algorithm and software for objects recognition by medical UAV*

As mentioned above, the authors developed the UAV with a container for medical care in extreme conditions; they proposed module options and their configuration in accordance with the task. To find a programmatically defined object or person, a person (face, object) recognition using a web camera were used; the system acts as a face detector and/or object detector. The algorithm of these processes sequences is as follows. First, the camera, using the written software, determines the appearance of a person or object and "captures" its image. Next, two possible schemes of operation of the face or object recognition module were implemented: identification or verification. The program codes presented below were written in Python using tecniques, described at online drone programming courses [16]. Below there are samples of created software, developed by the authors. Namely, there are the fragments of such developed software for the implementation of only three basic processes (in reality the authors created a set of such processes; so the algorithm can include numerical fragments and even now is more complicated). So, below one can see the steps: 1) "Reading and analyzing the image from the camera", 2) "Observation" and 3) Person (face, object) tracking":

1) Reading and analyzing the image from the camera.

2) Observation.

3) Person (face, object) tracking.

1. Reading and analyzing the image from the camera

```
from djitellopy import tello
import cv2
me = tello.Tello()
me.connect()
print(me.get_battery())
me.streamon()
while True:
    img = me.get_frame_read().frame
    img = cv2.resize(img, (360, 240))
    cv2.imshow("Image", img)
    cv2.waitKey(1)
```

2. Observation

```
from djitellopy import tello
import KeyPressModule as kp
import time
import cv2
kp.init()
me = tello.Tello()
me.connect()
print(me.get_battery())
global img
me.streamon()
def getKeyboardInput():
    lr, fb, ud, yv = 0, 0, 0, 0
    speed = 50
    if kp.getKey("LEFT"): lr = -speed
    elif kp.getKey("RIGHT"): lr = speed
    if kp.getKey("UP"): fb = speed
    elif kp.getKey("DOWN"): fb = -speed
    if kp.getKey("w"):ud = speed
    elif kp.getKey("s"): ud = -speed
    if kp.getKey("a"):yv = -speed
    elif kp.getKey("d"): yv = speed
    if kp.getKey("q"): me.land(); time.sleep(3)
    if kp.getKey("e"):  me.takeoff()
    if kp.getKey('z'):
        cv2.imwrite(f'Resources/Images/{time.time()}.jpg', img)
        time.sleep(0.3)
    return [lr, fb, ud, yv]
while True:
    vals = getKeyboardInput()
    me.send_rc_control(vals[0], vals[1], vals[2], vals[3])
    img = me.get_frame_read().frame
    img = cv2.resize(img, (360, 240))
    cv2.imshow("Image", img)
    cv2.waitKey(1)
```

3. Face tracking

```
import cv2
import numpy as np
from djitellopy import tello
import time
me = tello.Tello()
me.connect()
print(me.get_battery())
me.streamon()
me.takeoff()
me.send_rc_control(0, 0, 25, 0)
time.sleep(2.2)
w, h = 360, 240
fbRange = [6200, 6800]
pid = [0.4, 0.4, 0]
pError = 0
def findFace(img):
    faceCascade = cv2. Cascade Classifier ("Resources/haarcascade_frontalface_default.xml")
    imgGray = cv2.cvtColor(img, cv2.COLOR_BGR2GRAY)
    faces = faceCascade.detectMultiScale(imgGray, 1.2, 8)
    myFaceListC = []
    myFaceListArea = []
    for (x, y, w, h) in faces:
        cv2.rectangle(img, (x, y), (x + w, y + h), (0, 0, 255), 2)
        cx = x + w // 2
        cy = y + h // 2
        area = w * h
        cv2.circle(img, (cx, cy), 5, (0, 255, 0), cv2.FILLED)
        myFaceListC.append([cx, cy])
        myFaceListArea.append(area)
        if len(myFaceListArea) != 0:
        i = myFaceListArea.index(max(myFaceListArea))
```

```
        return img, [myFaceListC[i], myFaceListArea[i]]
        else:
        return img, [[0, 0], 0]
def trackFace( info, w, pid, pError):
    area = info[1]
    x, y = info[0]
    fb = 0
    error = x – w // 2
    speed = pid[0] * error + pid[1] * (error – pError)
    speed = int(np.clip(speed, -100, 100))
    if area > fbRange[0] and area < fbRange[1]:
        fb = 0
    elif area > fbRange[1]:
        fb = -20
    elif area < fbRange[0] and area != 0:
        fb = 20
    if x == 0:
        speed = 0
        error = 0
    #print(speed, fb)
    me.send_rc_control(0, fb, 0, speed)
    return error
#cap = cv2.VideoCapture(1)
while True:
    #_, img = cap.read()
    img = me.get_frame_read().frame
    img = cv2.resize(img, (w, h))
    img, info = findFace(img)
    pError = trackFace( info, w, pid, pError)
    #print(“Center”, info[0], “Area”, info[1])
    cv2.imshow(“Output”, img)
    if cv2.waitkey(1) & 0xFF == ord(‘q’):
        me.land()
            break
```

IV. CONCLUSIONS

Summarizing the results of the work done, the next conclusions can be done.

1) When performing this work, a person (face, object) recognition using a web camera was used to find a programmatically defined object or person.

2) Created system functions as face detector and/or object detector. First, the camera, using the written software, determined the appearance of a person or object and “captures” its image.

3) Next, two possible schemes of operation of the face or object recognition module were implemented: identification and/or verification.

4) The algorithms for these tasks were developed.

5) The corresponding software was developed and written too. This article presented fragments of such developed software for implementing of three basic processes: 1) “Reading and analyzing the image from the camera”, 2) “Observation”, and 3) “Person (face, object) tracking”.

6) Recommendations for using obtained results. UAVs with medical containers can be recommended for implementation in the spheres of activity of the Ministry of Health of Ukraine, the Ministry of Emergency Situations of Ukraine, the Ministry of Defense of Ukraine. The results of the work done can also be applied in the educational process of universities of Ukraine.

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В. М. Шутко. Б. Д. Москаленко, О. М. Ключко, А. Г. Лізунова. Технологія розпізнавання об'єктів дронами, що транспортують гуманітарний медичний вантаж

Розглянуто проблеми розпізнавання об'єктів дронами (БПЛА), проведено загальний аналіз цих проблем. Окреслено основні цілі роботи, а також перелік завдань для їх вирішення. У процесі роботи проведено дослідження прототипів та аналогів – версій раніше побудованих модулів БПЛА з можливостями розпізнавання зображень для надання медичної допомоги в екстремальних умовах. Метою цієї роботи була розробка механізмів та можливостей розпізнавання зображень БПЛА для медичних цілей, а також уточнення можливості транспортування гуманітарних вантажів БПЛА до програмно визначеного об'єкта або особи. Для цього враховано досвід створення прототипів та їх аналіз. Розроблено алгоритми необхідних операцій та відповідне програмне забезпечення для автоматизації процесів. Розроблене програмне забезпечення було розроблено на основі технології розпізнавання облич згортковою нейронною мережею. Детально описано всю необхідну інформацію щодо всіх етапів роботи. Спочатку розроблений гуманітарний БПЛА був побудований з різними модулями (для діагностики стану здоров'я людини, надання пацієнту відповідної медичної допомоги тощо); одним з них був модуль для розпізнавання зображень у точці призначення. У цій статті наведено приклад створеного алгоритму та кілька фрагментів нового програмного забезпечення. Розроблений БПЛА може бути використаний багаторазово для вирішення різних завдань: моніторинг забруднення місцевості (хімічного чи іншого); медичне обладнання та засоби першої допомоги можуть бути скинуті на парашутах над місцем розташування потенційно постраждалої особи тощо. В обох випадках для дрона бажано використовувати функції розпізнавання зображень. Описано попередні дані щодо успішного застосування результатів роботи, надано деякі практичні рекомендації.

Ключові слова: моделювання; безпілотний літальний апарат; дрон; функціональний модуль; конструювання; медичний вантаж.

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