칼만 필터와 LED 점멸 패턴을 이용한 드론 추적 및 인식 시스템

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Tracking and Identification of Drone System using Kalman Filtering and LED Blinking Pattern

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요 약

We proposed new method for identifying drones by using LED light pattern as a license plate. This technique can be useful for an identification process in any environmental circumstances. In this paper we described how drones can be modified and identified easily by using a mobile camera in the live stream. It is very simple and understandable for public use. For detecting and tracking drones Kalman filter is applied. Kalman filter used for to avoid inaccurate detection and to get a stable detection of blinking lights. The approach is based on Visible Light Communication which is becoming an accessible nowadays technical trend.

1. 서론

In this paper new identification method is recommended with the aid of using LED (Light-Emitting Diode) lights pattern as a license plate for drones. There are a various type of detection and identification techniques in different situation. For example, QR Code and RFID technologies, Audio, Visual, Thermal, Radar and Wi-Fi [1] methods are using for detection and identification process. Using LED blinking pattern while detecting and identifying drones may give us better results rather than other methods and it will not require special equipment's like signal based Radar, Camera with 4K feature and so on.

This article consists of following sections: our suggested drone identification structure explained in system overview section. In the next paragraph LED transmitter and receiver parts are described. The experimental outcomes are discussed in following section, and finally brings to end with a conclusion.

2. 관련연구

Since there are a large number of LEDs deployed/used outdoors as well, street lights, traffic lights, and vehicle lights are also applicable for establishing VLC wireless links among vehicles, vehicle and roadside lighting infrastructure, vehicle and traffic lights [2, 3]. Since the vehicle is usually equipped with an image sensor array, it can predict its relative motion together with data transmission. Originally the new method idea taken from Car License Plate Number (Fig. 1.), to give for each drone identical numbers like used for identifying cars.

Fig. 1. Car License Plate Number.

3. 제안한 방법의 구조

In this case as a LED transmitter part microcontroller and array unit are used (Fig. 2.):

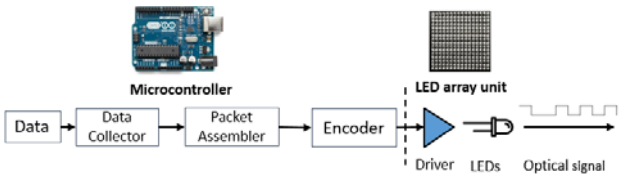


Fig. 2. LED transmitter unit.

As a LED transmitter part of this system Flexible RGB LED Matrix 16x16 is applied with Arduino Uno. The proposed idea of drone identification method originally taken from Car License Plate Number as mentioned above

applying ASCII signs (numbers and letters only) and encode these figures as a RGB blinking light sequence. For encoding only R (red), G (green), and B (blue) blinking lights used, in order to be simple identification, and time limit. In this case the total ASCII displays 36 figures for registration of drones as a license number A~Z, 0~9 and ASCII to optical signal RGB. For changing figures to optical signal ASCII&RGB table created manually (Table 1):

Table 1. ASCII&RGB table.

No.	Sign	RGB 4 bits Encoder	No.	Sign	RGB 4 bits Encoder	No.	Sign	RGB 4 bits Encoder	No.	Sign	RGB 4 bits Encoder
1	A	RRRR	10	J	RGRR	19	S	RBRR	28	1	GRRR
2	B	RRRG	11	K	RGRG	20	T	RBRG	29	2	GRRG
3	C	RRRB	12	L	RGRB	21	U	RBRB	30	3	GRRB
4	D	RRGR	13	M	RGGR	22	V	RBGR	31	4	GRGR
5	E	RRGG	14	N	RGGG	23	W	RBGG	32	5	GRGG
6	F	RRGB	15	O	RGGB	24	X	RBGB	33	6	GRGB
7	G	RRBR	16	P	RGBR	25	Y	RBBR	34	7	GRBR
8	H	RRBG	17	Q	RGBG	26	Z	RBBG	35	8	GRBG
9	I	RRBB	18	R	RGBB	27	0	RBBB	36	9	GRBB

Applied 3 color channel R, G, B for permutations with repetition for 1 of 36 figures and because of 36 figures RGB 4 bits Encoder is used. For example, 3 bits 3x3x3=27 cases, RRR to BBB and 4 bits 3x3x3x3=81 cases 4 sequences of RGB, e.g. RRRR encode as “A” of 36 figures “A~Z, 0~9”.

The vehicle license plate consists of 7 signs, includes numbers and letters (Fig. 1.): Y1D0463. Generally the amount of license number depends on the drone manufacturing company and government agreement. RGB plate has 7 figure which includes payload 4x7=28 bits, preamble 4 bits, and post amble 4 bits total 36 RGB bits. The structure of one blinking LED’s package shown in Figure 3.:

Preamble 4 bits RGBG	Payload 28 bits	Post amble 4 bits GRBG

Fig.3. Package structure.

A blinking LED package structure consists of 3 part as shown Figure 3. It blinks with 3 different colors: red, green, and blue, each color blinks 68ms (BT). Header and footer part of the blinks without pause time, payload part of the package has different pause time, Pause Time 1(PT1=48ms) and Pause Time 2(PT2=38ms). PT1 used after each figure and PT2 used for example: Y ~ R [PT2] B [PT2] B [PT2] R. Complete blinking sequence for one package takes 3.63 second: Total time=0.068*x+(x-14)*0.038+8*0.048≈3.63 sec. Detailed structure of the blinking package shown below in Figure 4:

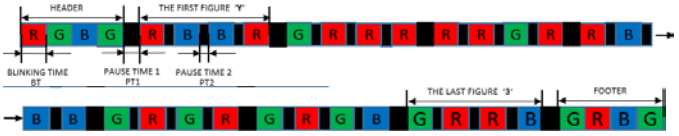


Fig. 4. Structure of the blinking sequence package (one)

Next part is a LED light blinking receiver, as a tracker mobile camera used. Receiver part consists of a mobile camera (applying a camera depends on the target) and LED light identifying software system. The camera receiver system structure shown in Figure 5. :

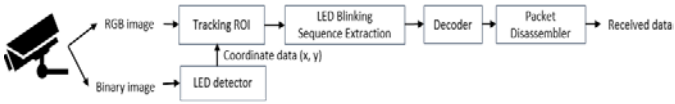


Fig. 5. Proposed Camera receiver system

For instance, in the first step detects LED and starts tracking, in this case a Kalman filter used. Currently, there are some tracking and detecting algorithms, methods are developed. Kalman filter is one of the most useful algorithm for tracking purposes. The Kalman filter estimates the state by minimizing the error of the current value and the value estimated from the previous state [4].

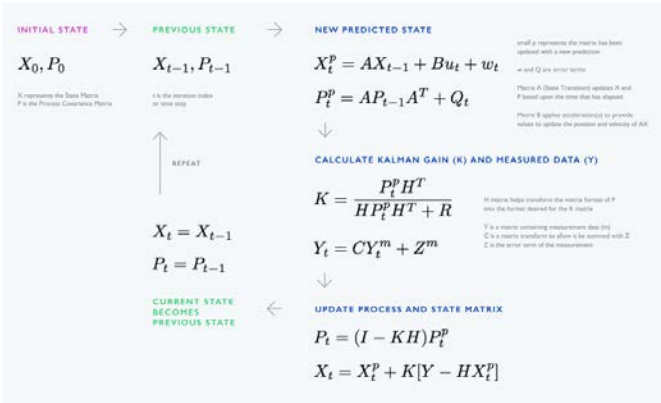
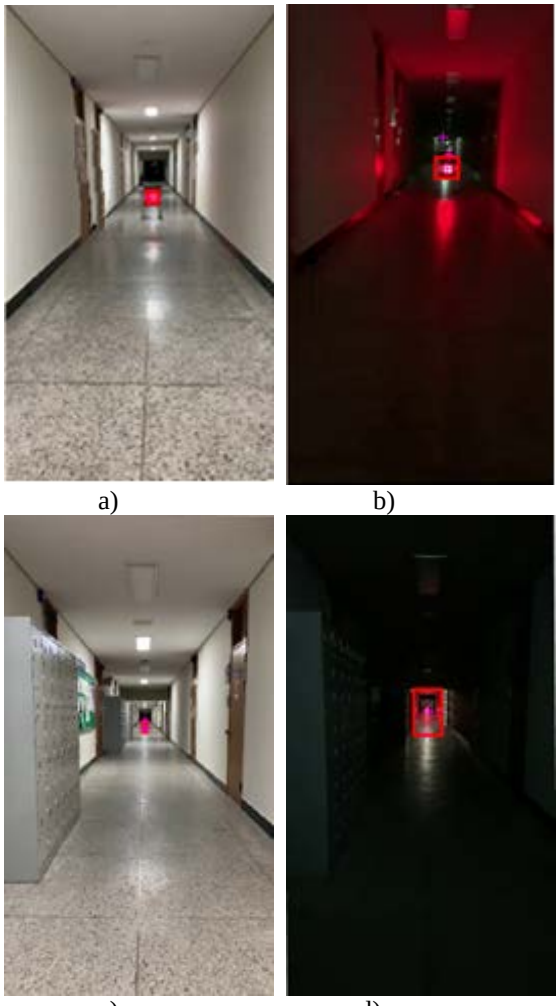


Fig. 6.Process of Kalman filtering [5].

This Kalman filter structure similar to our used code performance which was explained in detail here [5].

4. 실험 결과

Because of some inconvenient setting, to get the outcomes of the experiment become somehow difficult. LED array blinking tested on the ground surface, however, good results have been achieved. Initially, from video all image frames extracted and the coordinate of the blinking LED’s detected. A tracking process have been tested five different distances: 10, 20, 30, 40, and 50 meter cases, also day and night mode. Firstly, the coordinate of the blinking LED’s and its center detected (Fig. 7.). In order to be clear there are only shown the results of 10 meters (day and night mode) and 50 meters (also day and night mode):

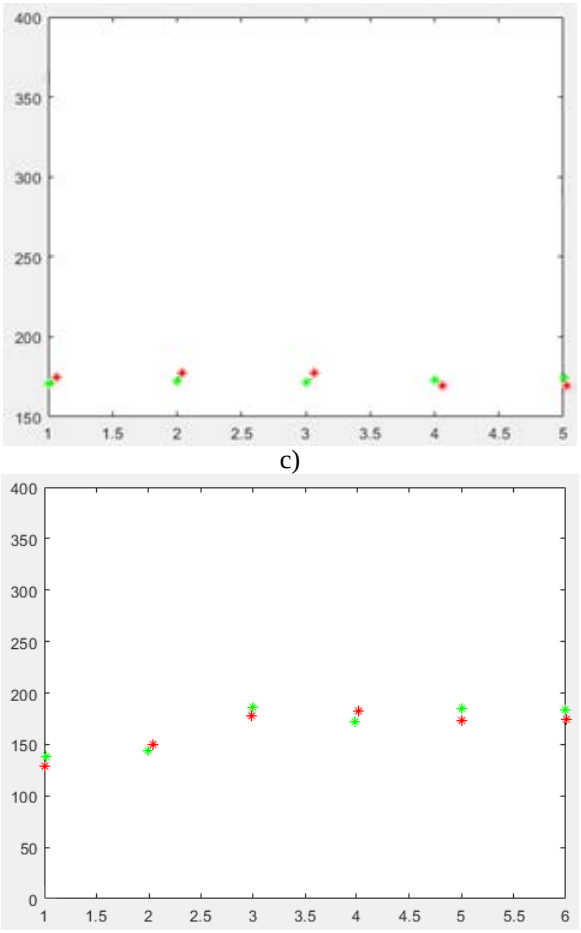


a) b) c) d)

Fig. 7. Coordinate of the LED light blinking (x, y), a) – 10 meter, day mode; and b) – 10 meter night mode c) – 50 meter day mode; d) – 50 meter night mode; detecting center of the blinking LED.

After detecting the center of blinking LED light, than a tracking process has been performed. As a tracking method Kalman filter applied. The result of the tracking a LED light blinking from the video sequence shown in Fig. 8:

a) b)



c) d)

Fig. 8. LED Tracking with Kalman filter a) – 10 meter; b) – 50 meter (both day mode); c, and d respectively their position of tracking trajectory via histogram.

There are a lot of methods and algorithms for tracking objects, however proposed algorithm results was better than other methods for our case LED light tracking. There is one thing worth to mention that the Kalman filter also used for tracking traffic lights [6], but the thing is that the traffic lights do not move while detecting, and tracking camera or sensor should be installed to cars or any moving automobile. In this case some part of Kalman filter should be changed to track horizontally only.

5. 결론

To conclude with, we have proposed a new method for identifying drones by using LED light pattern as a license plate, and this technique can be useful, ordinary, secure, and the cheapest way of identifying drones by using cars license number as an ID number by transforming them into blinking. In this paper we described how drones modified and can be identified easily by using a mobile camera on the live stream. It is very simple and understandable for public use.

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