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ELDOC - Design of Electric Dolly Camera for Video Recording Using the Omni-Direction Wheel

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Abstract

The dolly camera has function as a regulator of camera movement in making video productions such as films. The movement system on the dolly camera uses the thrust of humans and the running track rail for its movement. The process of preparing the dolly camera also requires a long process, such as assembling the dolly camera and then installing the track, etc. In this case study, we conducted research that designed an electric vehicle to carry a camera but with a simple way of working such as moving without rails and can be controlled with a mobile android. We named this robot vehicle ELDOC: Electric Dolly Camera which uses a four Omni-direction wheels system in the flexibility of direction and motion for taking videos and pictures. Contributions to the design of ELDOC in addition to the multimedia/cinematography field can also be used in the medical field as a monitoring tool for patient activities in isolation or ICU room with a mobile android from different rooms. In the results of the process running on the motor, we take error data from the calculation speed and measurement speed, wherein the duty circle is 19.60%, 38.50%, 58.8%, 78.66%, and the average error is 0.08. The stability level of the ELDOC when carrying the camera is stable but has vibrations or oscillations. The results of the data orientation (gyroscope) show the total average of the three samples Y (Roll) orientation is 0.6°/s and X (Pitch) orientation is 0.18°/s.

Keywords: Dolly Camera, Electric Vehicle, Omni-direction Wheel, Robot

1 Introduction

The global TV and Film sector has a market revenue of $585B, 36% or $215B invested in new content generation (Oliver and Ohlbaum, 2018). Global investment in the TV and Film industry recognizes that in high-quality production one of them relies on technological innovation (Uday et al., 2018). This shows that technological innovation (especially in the field of robotics) must continue to influence our society (Ge et al., 2011), entertainment (Hajjaj and Karim, 2021), medical (Giansanti, 2021), education (Lu et al., 2018), etc. At the present time related to film production, the development of technology for shooting such as dollies is not much new and mostly focuses on improving the image (Orito et al., 2020).

Camera movement is very important in shooting and has an influence on the value of video/film production. Human stability in holding and taking pictures is impossible to achieve perfect, so it requires new innovations about shooting picture/video. Previously, the development of electric or robotic vehicle dolly cameras still used rollers/rails or cushion blocks for walking tracks (Hajjaj and Karim, 2021, Alveteg and Adeeb, 2019). The realization of designing a walking track for a dolly camera takes a long time (see Figure 1). Therefore, researchers have an idea to design an electric vehicle dolly using an Omni-direction wheel. The main goal is to use an Omni-direction wheel for efficiency in use and flexibility in moving. Besides being able to be used in the TV/film sector, it can also be used in other sectors such as for health, for example to recording video condition patients in the isolation or ICU room.

Figure 1. Dolly camera which has existed (a) Manual-operated (*Hague D5T Camera Tripod Tracking Dolly Kit*, n.d.), (b) Controllable dolly camera (Alveteg and Adeeb, 2019), (c) IoT-enable Robotic Dolly Camera (Hajjaj and Karim, 2021).

In this paper, we conducted research that designed an electric vehicle to carry a camera but with a simple way of working such as moving without rails and can be controlled with a mobile android.

2 Material and Method

The method used in this research consist of mechanical design, hardware design, and direction of motion algorithm design.

2.1 Mechanical Design

Mechanical design for holonomic-based ELDOC using four omni-direction wheels (Oliveira et al., 2009, Qian et al., 2017). The purpose of using four omni-direction wheels is so that the vehicle in carrying the camera moves flexibly in various 2D directions, X and Y coordinates (Chia-Wen Wu et al., 2009). The length of the ELDOC radius from the center of the body to the wheel is 380 mm. The robot is made with these dimensions with the aim of following the maximum expansion of the tripod. The position of the camera will be in the middle of the ELDOC which aims to make it easier to synchronize the camera capture process with the motion of the camera movement. the design and the results can be seen in Figure 2.

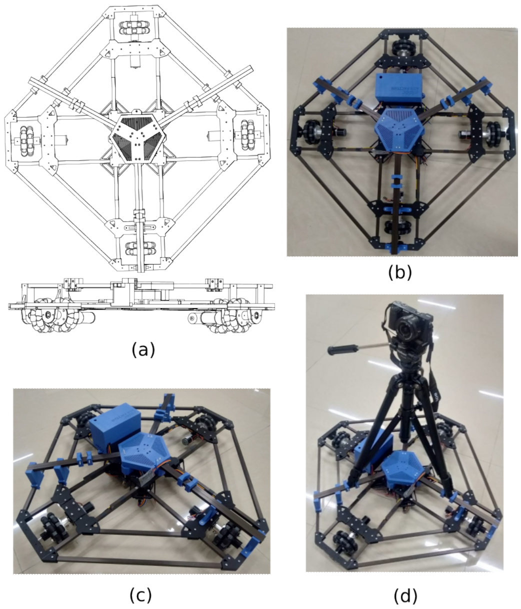

Figure 2. (a) 2D CAD mechanical design, (b) 3D CAD mechanical design, (c) Realistic mechanic chassis, (d) ELDOC with tripod and camera

The main mechanical parts of the ELDOC consist of the ELDOC chassis frame, actuators, tripod mounts, hardware/electronic compartments, and batteries. Mechanical material specifications are described in detail in Table 1.

2022). Details of the first hardware and wiring design on the Bluetooth HC-05, the pins used are TX, RX, VCC, GND connected to pins D19, D18, 5V, GND on the microcontroller (Oprea and Mocanu, 2021).

Table 1. Detail of Mechanical Parts

Part	Materials	Size
Main Frame/Chassis	Brown Hollow Aluminium	L11 x W11 x T1 mm
Frame/Chassis Connector	3D Filamen PLA (Blue & Black)	d1.75 mm
Motor DC	Tipe 37GB 24V 140rpm (Torque = 11,2 kg)	AS d6 mm
Hub Motor DC	Aluminium	
AS Wheel	AS stainless steel	d10 x L100 mm
Double Omni-direction wheels	Plastic and rubber	d100 mm
Bearing	Stainless steel	d25/10 mm
Nut and Bolt	Alloy Steel	3, 4, and 6 mm

2.2 Hardware and Electric Design

ELDOC's Hardware/electronics uses Arduino Mega 2560 series microcontroller (Yunardi et al., 2021), BTS7960 motor driver, and Bluetooth HC-05. The use of Bluetooth which is connected to the microcontroller as a receiver from the transmitter on the Android mobile Bluetooth, here the Android mobile is used as a joystick (Thote et al.,

In the BTS7960 motor driver (Syukriyadin et al., 2018, Pham et al., 2022), the L_EN and R_EN pins are used for setting the PWM value (Divakar et al., 2016) with a 5V output (range 1-255) so that it is connected to the PWM microcontroller pin (Dadi et al., 2021) in sequence starting from the motor driver 1 to 4 on pins D2, D3, D4, and D5. The motor driver is used as a reverse and forward enable where each motor is connected to a digital pin on the

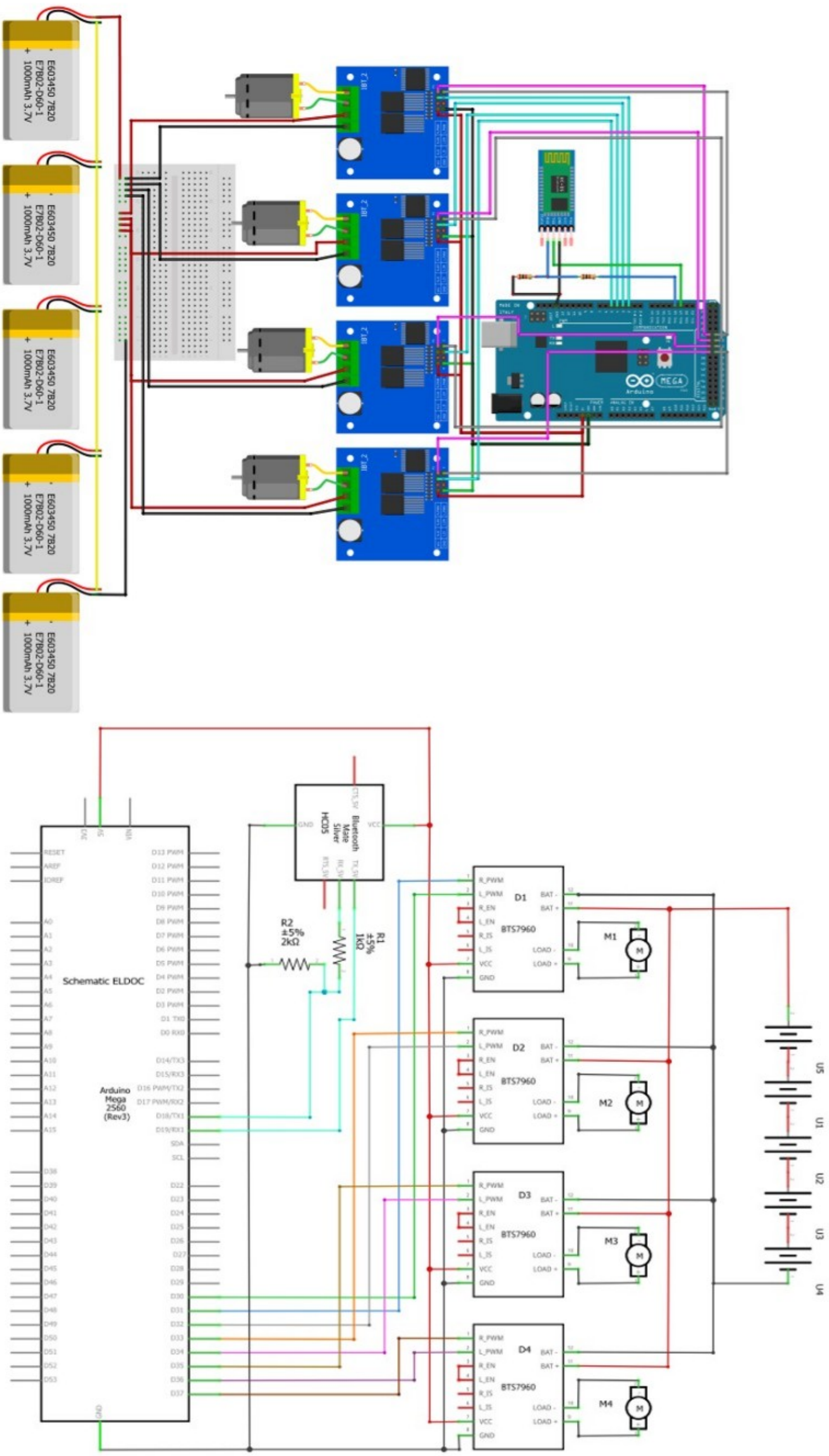

Figure 3. Hardware and Electric Design

microcontroller, namely the LPWM and RPWM pins on the motor driver 1 to 4 is connected to pins D30 to pins. D37. The motor supply pin is connected to a 24 V Lithium ion battery according to the power requirements of the DC motor. The design of harware and electric are shown in Figure 3.

The power supply used is 28 Lithium-Ion 18650 cell 3.7V 1200mAh batteries which are arranged in parallel and in series so that they become 7 cells, the voltage value is 24V, the power value is 20A. The battery has a BMS (Battery Management System) safety for charging and discharging automatically to the battery so that overcharging does not occur (Cheng et al. 2011). Figure 4 shows the design of the power supply.

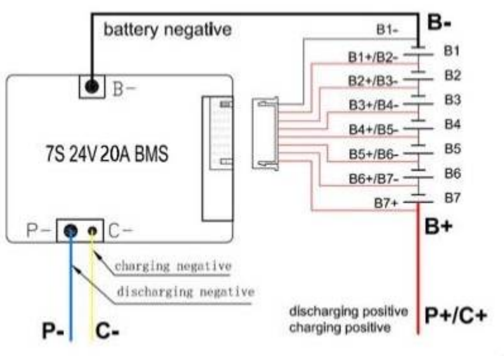

Figure 4. The Power Supply

2.3 Motion and Algorithm

The movement of the ELDOC wheel gets commands from the joystick apps on the Android mobile via Bluetooth. There are two settings used, namely speed control and direction of motion. The rotational speed of the motor used is 1 to 140 rpm. The movement of the wheel direction on the ELDOC applies a holonomic plus/X drive (Yunardi et al. 2021) (Batlle and Barjau 2009). In the direction of displacement, ELDOC is divided into 8 directions (shown in Figure 5) according to the needs of the video/camera recording process, namely forward, back, right, left, back half right, back half left, forward half right, and forward half left.

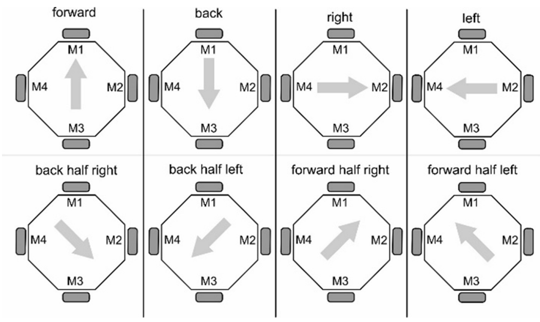

Figure 5. The Directions

The running condition of the ELDOC (wheel/command) adjusts to the direction of the Android mobile command. In Algorithm 1, each configuration direction has a motor rotation direction of 1 to 5 different adjust on the Figure 5.

Algorithm 1. ELDOC Direction of Motion

```
Connection with Bluetooth
function direction Motor ELDOC ()
   configuration PWM value
   If direction configuration
   android apps, then
      Motor1 direction
      Motor2 direction
      Motor3 direction
      Motor4 direction
   end if
end function
```

3 Experiment and Result

3.1 PWM Data Retrieval

PWM is the initial process of motor speed regulation. PWM data retrieval is carried out to equalize the speed of each DC motor and find out the error value in the calculated speed data and the measured speed data. This is done to reduce vibrations or oscillations when ELDOC is running, and the camera is recording. PWM signal data retrieval is carried out using an Oscilloscope type GW Instek GDS-2202 and wheel rotation speed data is taken using an Extech Tachometer (461920), which can be seen in Figure 6.

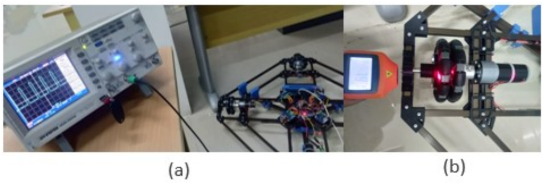

Figure 6. Data Retrieval with (a) Oscilloscope, (b) Tachometer

Equation 1 is used to measure the percentage error value of the calculated speed data and the speed data measured by the Tachometer.

$$error = \frac{v_c - v_m}{v_c} \times 100\% \qquad (1)$$

where v_c is the calculated speed and v_m is the measured speed. The measurement results of one sample of the PWM signals motor DC using an Oscilloscope are shown in Figure 7.

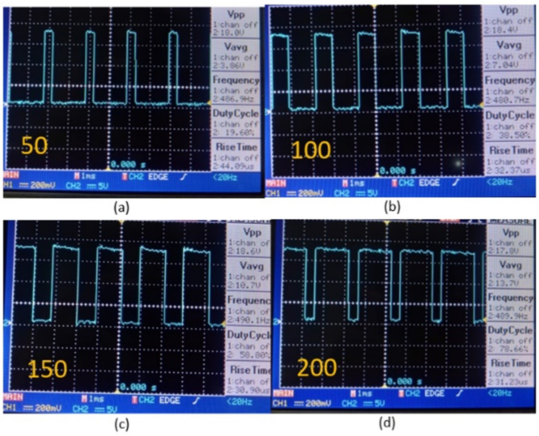

Figure 7. PWM Signal Data on The First Motor (M1)

The results of data collection for the measured speed and the calculated speed are different which results in an error value. The results shown in Table 2 have the highest percentage of error value 8.18% in a duty circle of 78.66%. This happens due to the condition of the Omni wheels which have an uneven texture so that the rotation data is not legible and must be re-measured several times. It is recommended to measure wheel rotation in future studies using a rotary encoder to get more accurate results.

Table 2. Error Values of The Speed

Duty Circle (%)	PWM (Desimal)	Speed Calculation (rpm)	Average Speed Measurement (rpm)	Error (%)
19,60	50	27	25,3	0.06
28,50	100	54	53,9	0.0018
58,80	150	82	79	0.036
78,66	200	110	101	0,08

3.2 Movement Direction Testing

This test is carried out to determine the movement of ELDOC in each direction of wheel rotation. The configuration of the direction of motion of the wheels is arranged according to Figure 5. The results state that it is on target so that it can be used as a reference for basic motion for vehicle robots that use four Omni direction wheels such as ELDOC. The results are shown in Table 3.

Table 3. Results of The Direction Testing

Motor Direction				ELDOC Direction	Results
M1	**M2**	**M3**	**M4**		
Stop	CW	Stop	CW	forward	conform
Stop	CCW	Stop	CCW	back	conform
CW	Stop	CW	Stop	right	conform
CCW	Stop	CCW	Stop	left	conform
CW	CW	CCW	CCW	back half right	conform
CCW	CW	CW	CCW	back half left	conform
CW	CCW	CCW	CW	forward half right	conform
CCW	CCW	CW	CW	forward half left	conform

3.3 Camera Stability Testing

The position and direction of the camera are set manually when the dolly condition has not been executed. Camera stability testing on ELDOC is used to determine whether the robot can walk straight and stable without any vibration or oscillation. Figure 8 is a visualization of data testing Y (Roll) and X (Pitch) Orientation, where the robot runs in the forward, right, and forward half left directions. Data retrieval using Orientation/Gyroscope (degree/s) on AndroSensor Xiaomi Redmi Note 10 5G which is placed above the camera in recording condition.

In taking orientation data (Gyroscope) in three sample directions, namely forward direction, right direction, and forward half left direction. The results obtained from each Y (Roll) and X (Pitch) orientation of the sample are as follows:

3.3.1 Forward Direction

From the results of the moving test with a time duration is 55 seconds and a speed of 28 rpm has an average offset value for Y (Roll) orientation is 0.43 degree/second and X (Pitch) orientation is 1.08 degree/second. The standard deviation value for Y (Roll) orientation is 3.58 and X (Pitch) orientation is 3.26.

3.3.2 Right Direction

From the results of the moving test with a time duration of 62 seconds and a speed of 28 rpm has an average offset value for Y (Roll) orientation is 0.45 degree/second and X (Pitch) orientation is 0.18 degree/second. The standard deviation value for Y (Roll) orientation is 1.85 and X (Pitch) orientation is 3.07.

3.3.3 Forward Half Left Direction

From the results of the moving test with a time duration of 55 seconds and a speed of 28 rpm has an average offset value for Y (Roll) orientation is 1.09 degree/second and X (Pitch) orientation is 0.34 degree/second. The standard deviation value for Y (Roll) orientation is 2.63 and X (Pitch) orientation is 2.11.

From the results of the overall data orientation (gyroscope), there is no more than 10 degrees with the total average of the three samples Y (Roll) orientation is 0.6 degree/second and the total average of the three samples X (Pitch) orientation is 0.18

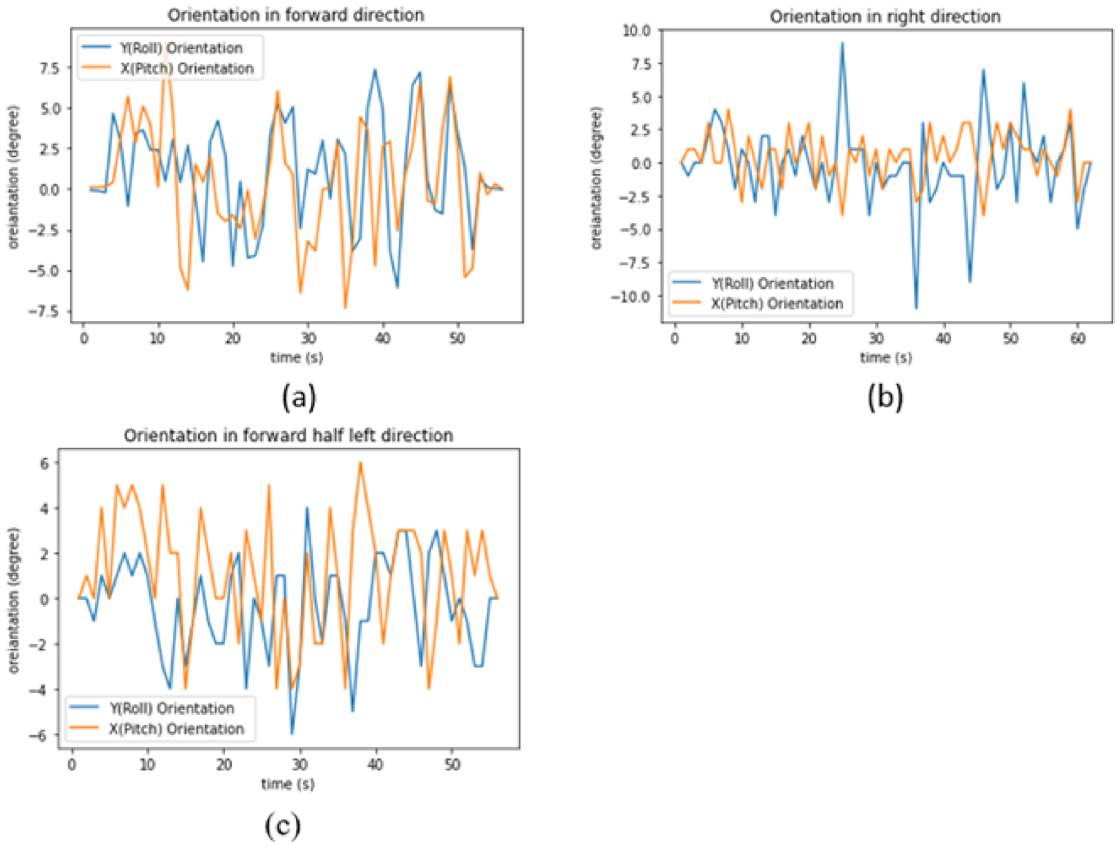

Figure 8. PWM Signal Data on The First Motor (M1)

degree/second which is considered stable, but the comparison level of data variation (standard deviation) and the average offset value shows that the stability result is not optimal. Judging from the process of taking pictures with this level of stability, it is still good compared to taking pictures with human motion. It is recommended for further research to use additional sensors and control systems such as PID, Fuzzy, etc.

4 Conclusion

Based on the results of testing and analysis of speed data from calculations and measurements, the average error value is below 0.08 with a duty cycle of 19.60%, 38.50%, 58.8%, 78.66% in the movement of the holonomic plus/X direction with four-omni direction wheels according to the desired target direction, namely 8 models.

The results of the orientation gyroscope data have an average total offset of the three samples at Y(Roll) which is 0.6 degree/second and X(Pitch) is 0.18, showing stable results but having vibrations or oscillations. It is recommended for further research to reduce oscillations with control systems such as PID, Fuzzy, etc.

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