

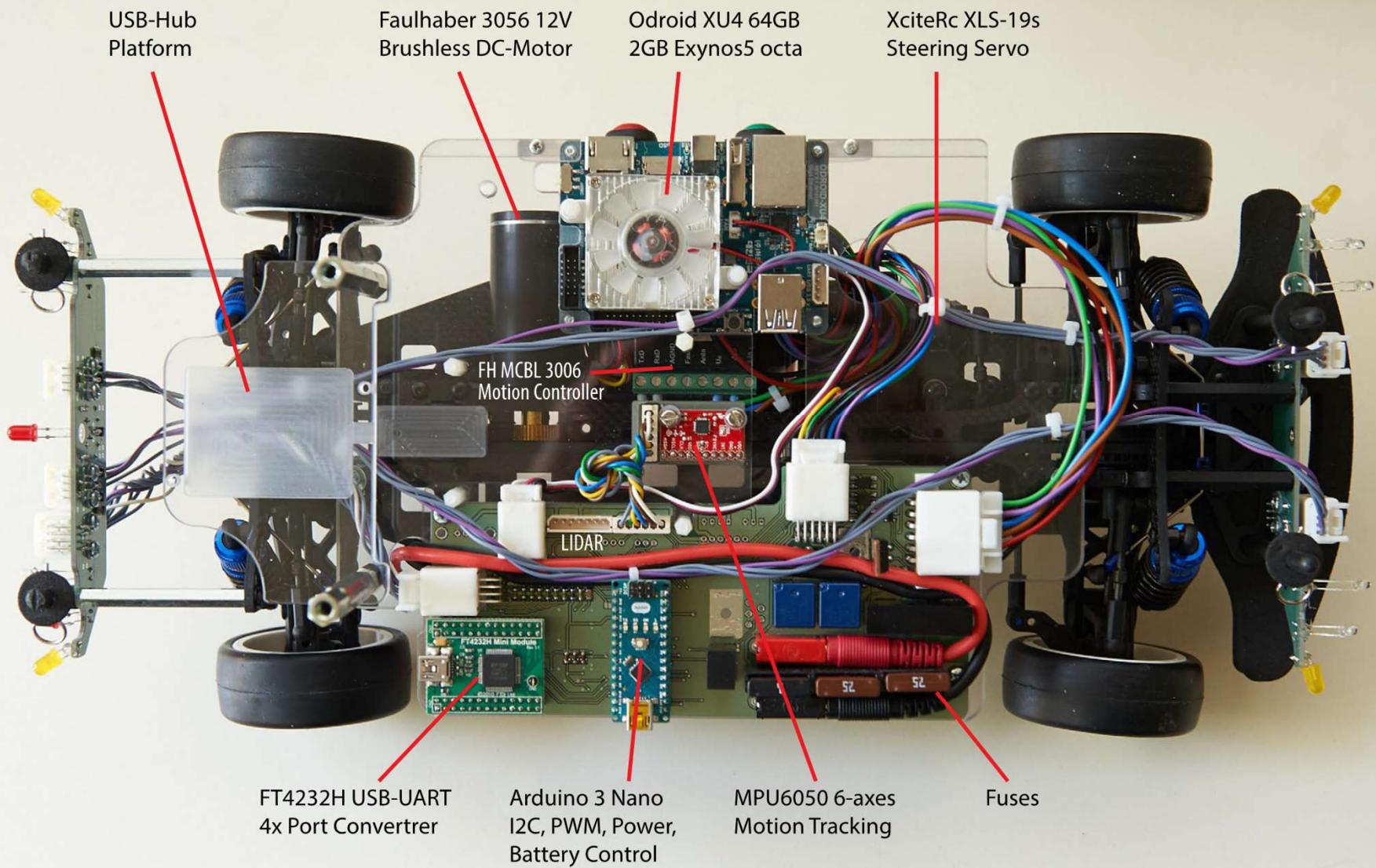
FU Berlin WS-17/18

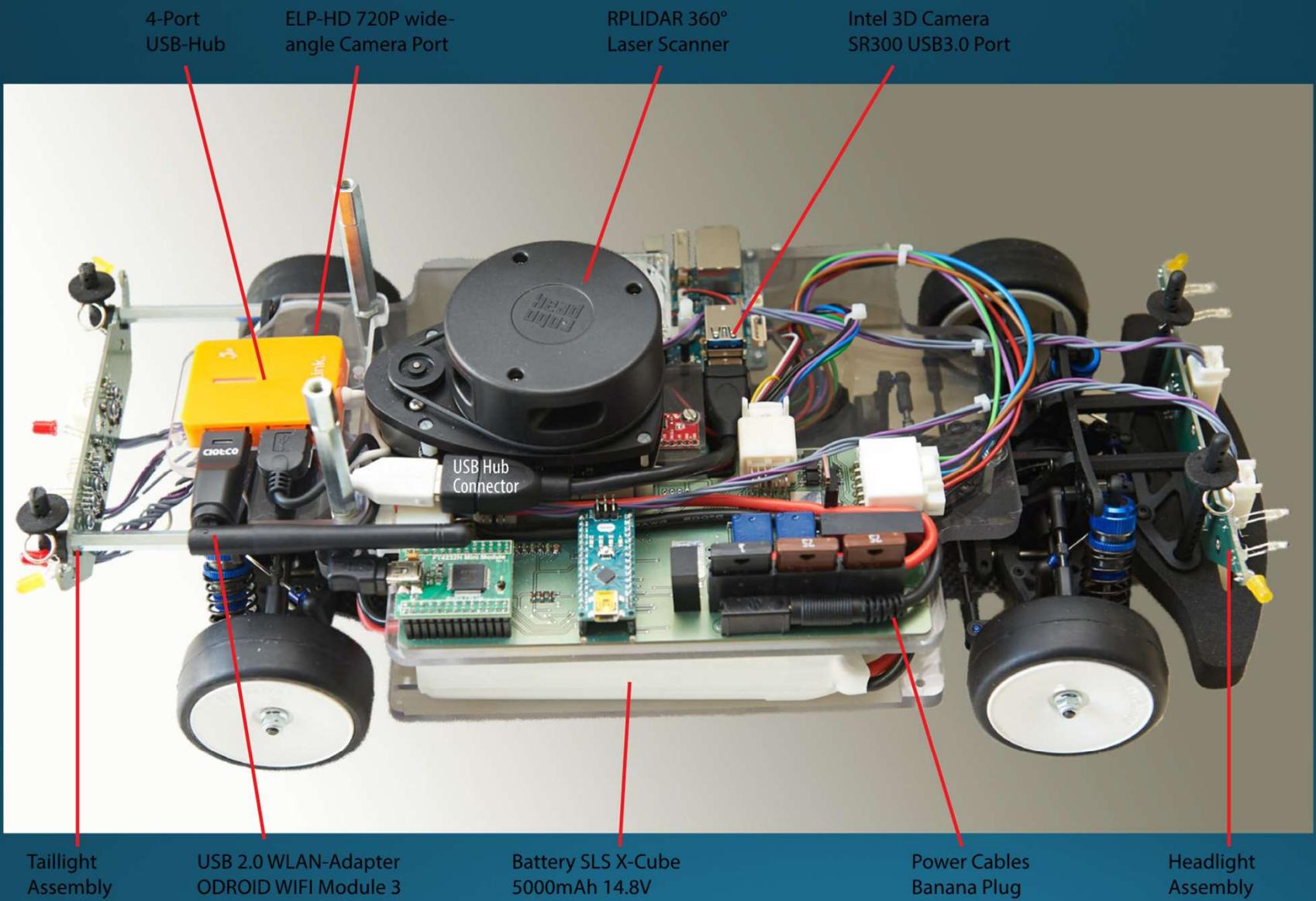
Robotics

Robotics = Systems Integration

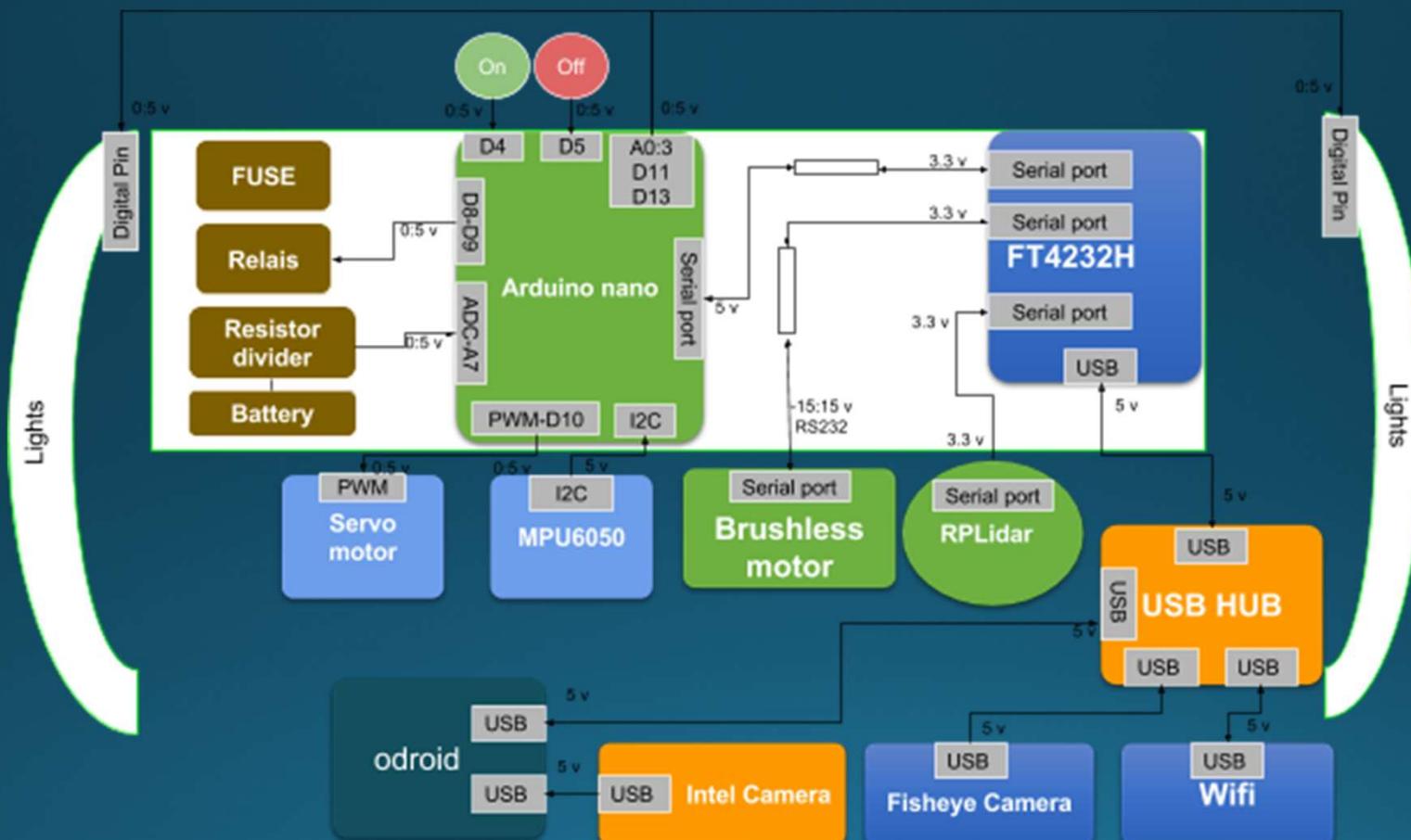
- Mechanical Body
- Sensors
 - Video cameras: image sensors
 - Monocamera
 - Stereo camera
 - Distance sensors
 - Laser scanner (Lidar)
 - Radar
 - Ultrasound
- Actuators
 - Motors
 - Servo motors
- Intelligence
 - Computer
 - Embedded processors







Electronics

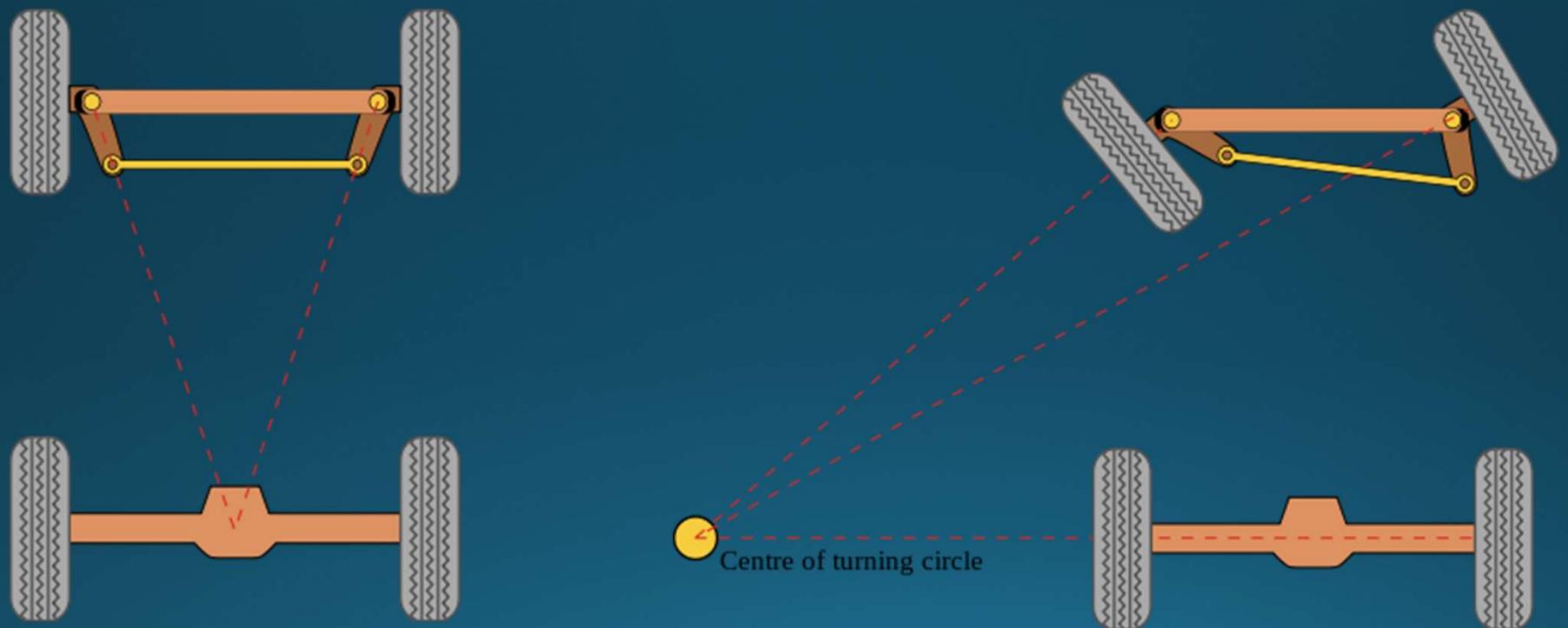


Chassis: RC car

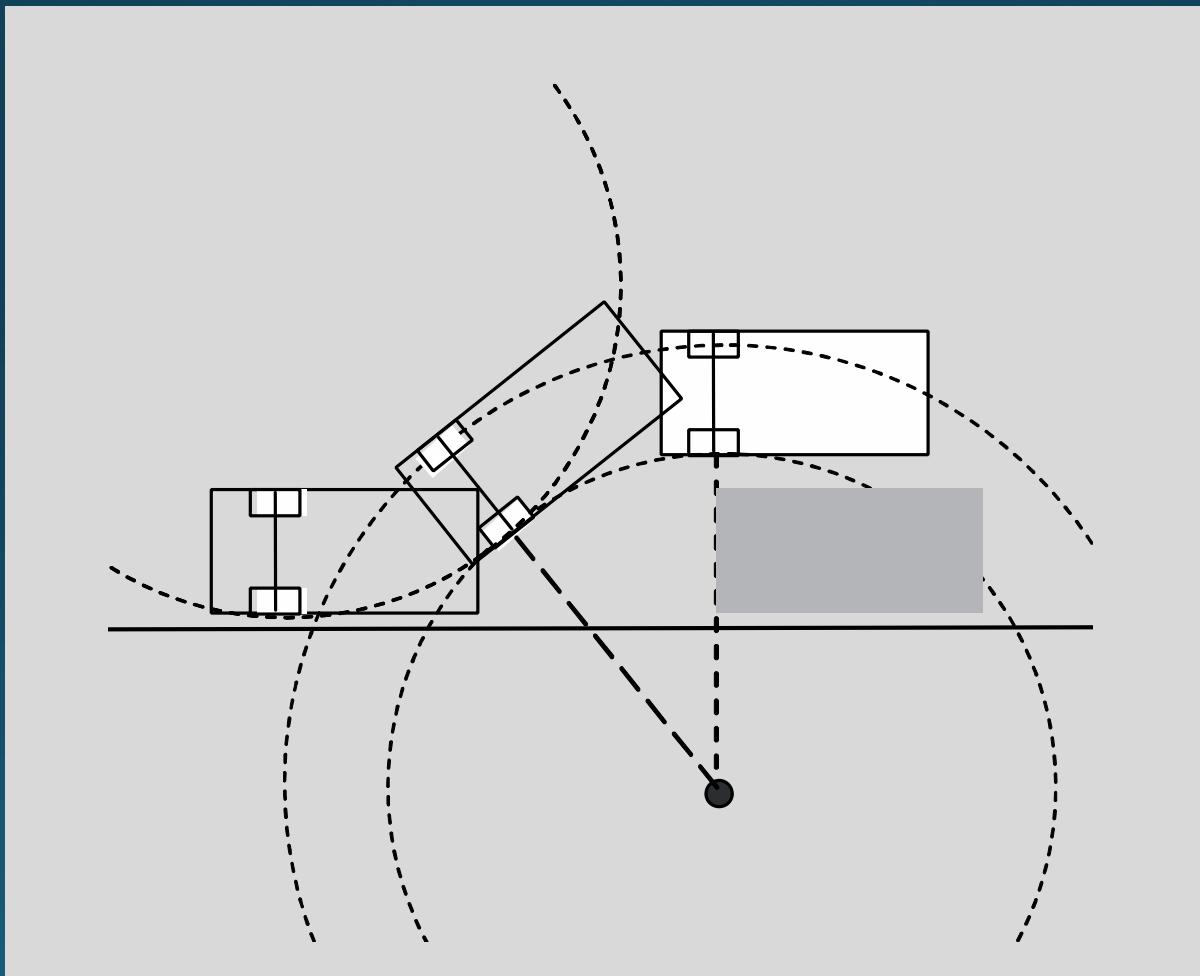


The mechanical body

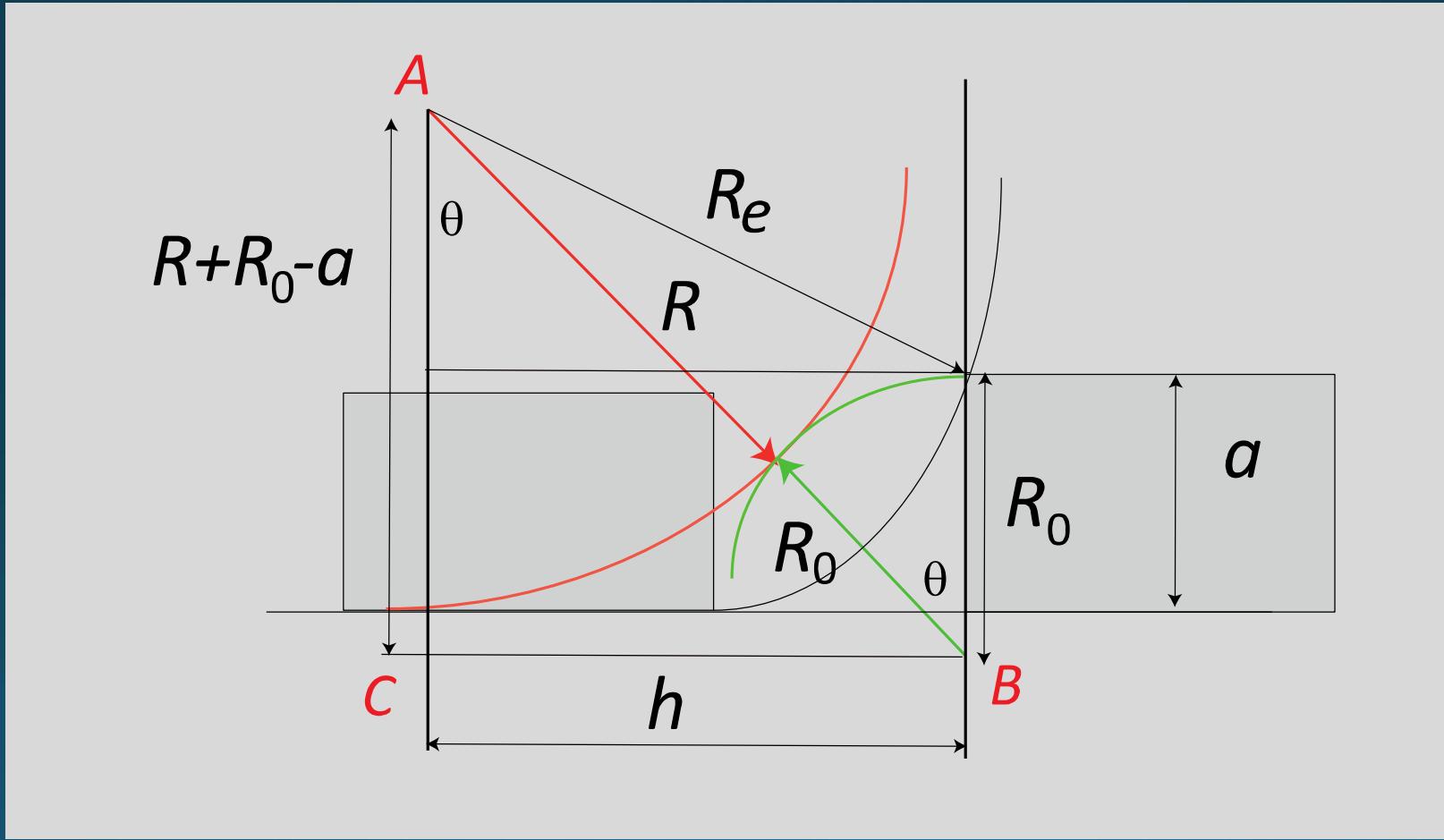
Chassis: Ackermann steering



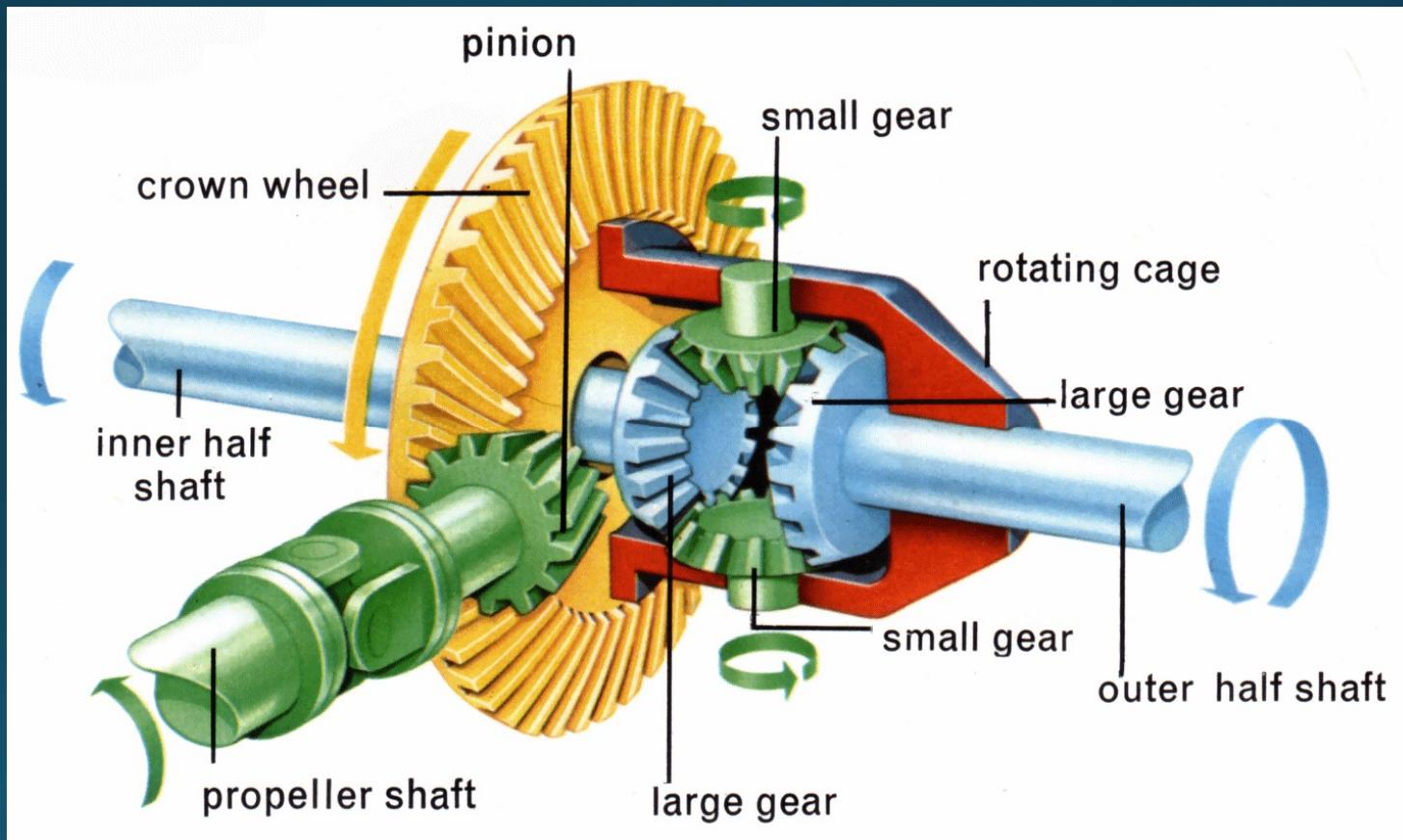
Cars drive in circles



Parking in two movements

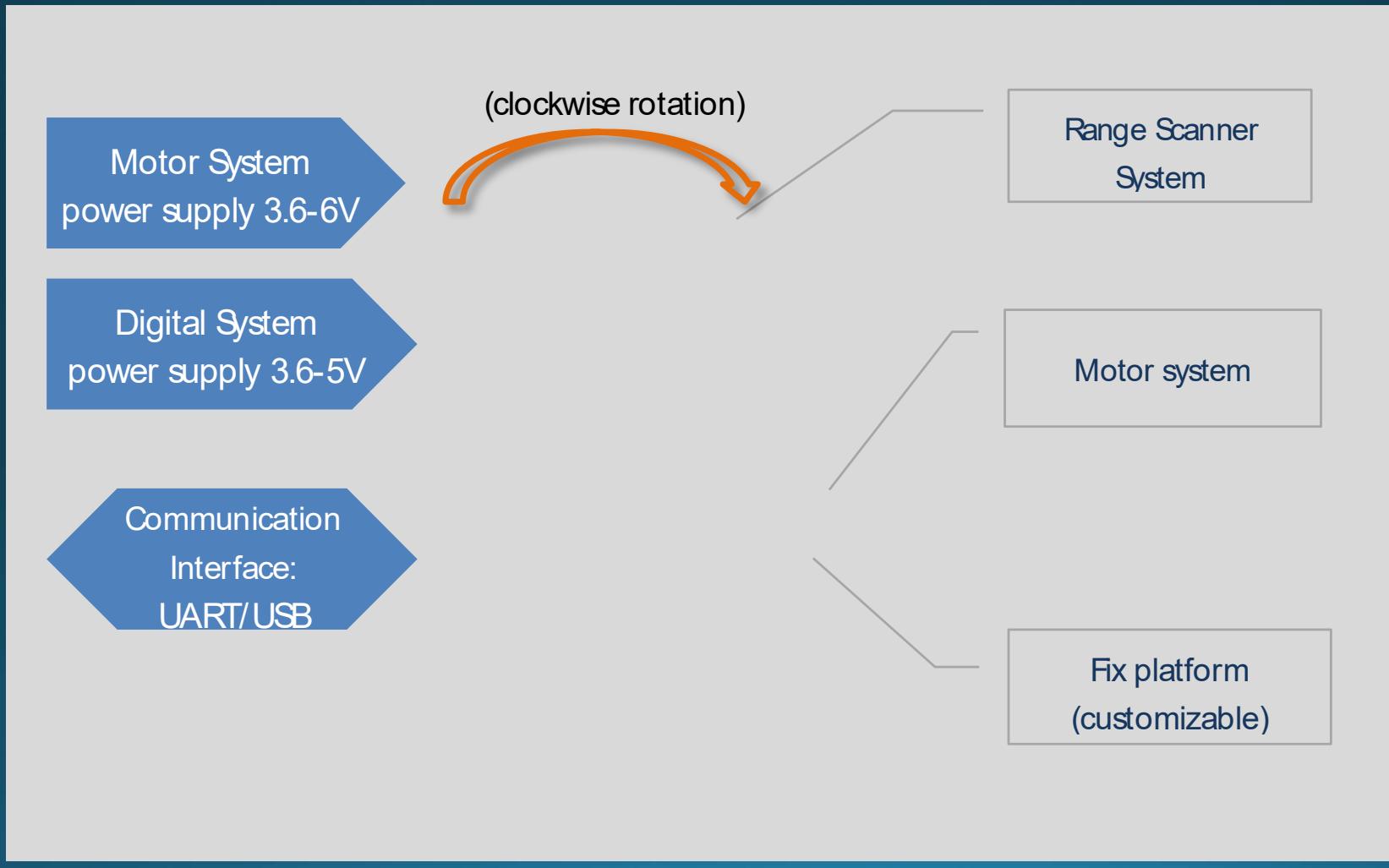


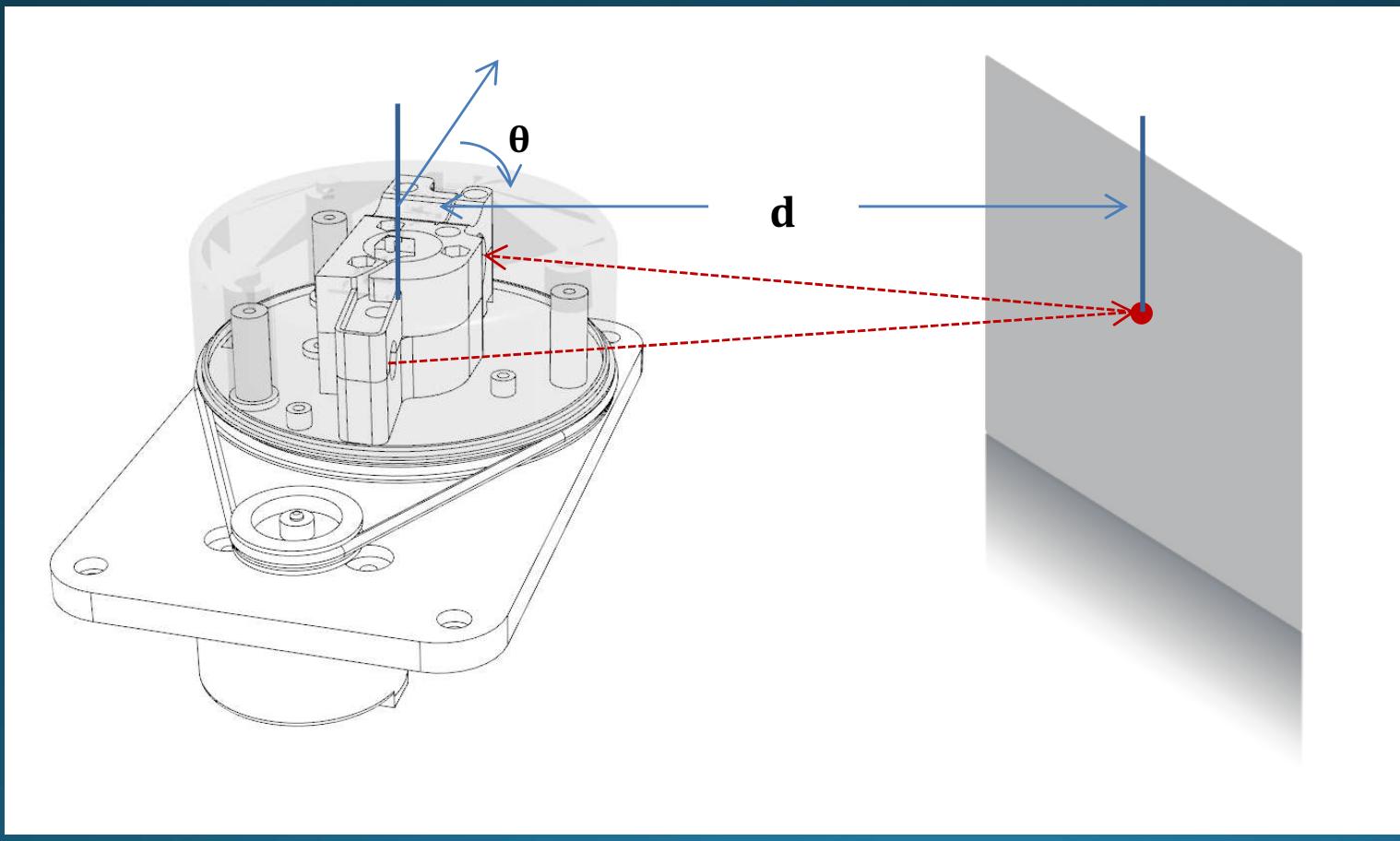
Differential drive



Sensors

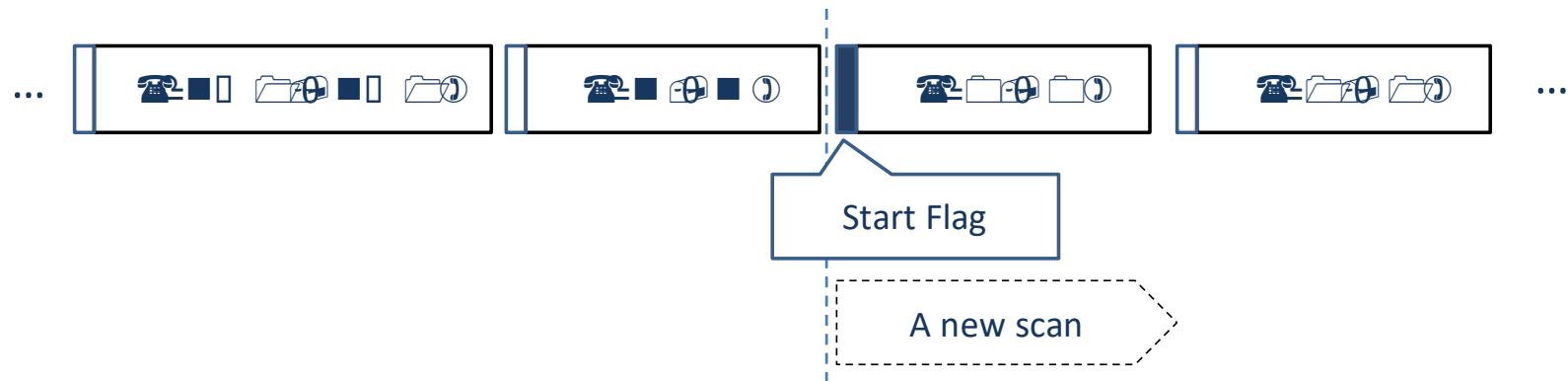
RP Lidar





Output data

Data Type	Unit	Description
Distance	mm	Current measured distance value
Heading	degree	Current heading angle of the measurement
Quality	level	Quality of the measurement
Start Flag	(Boolean)	Flag of a new scan



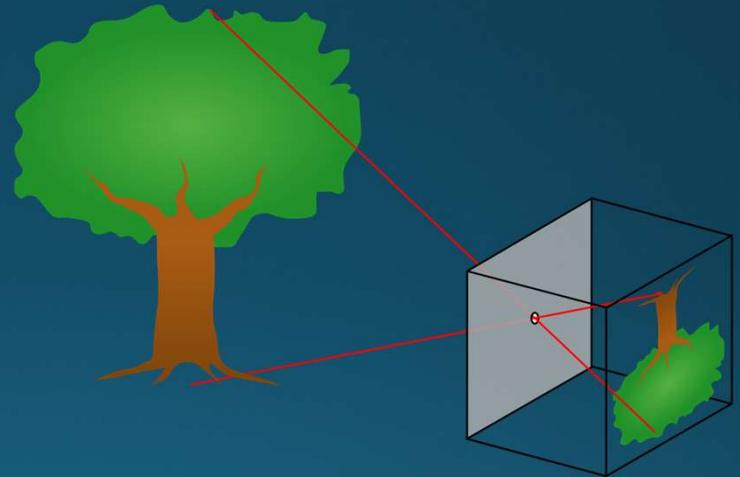
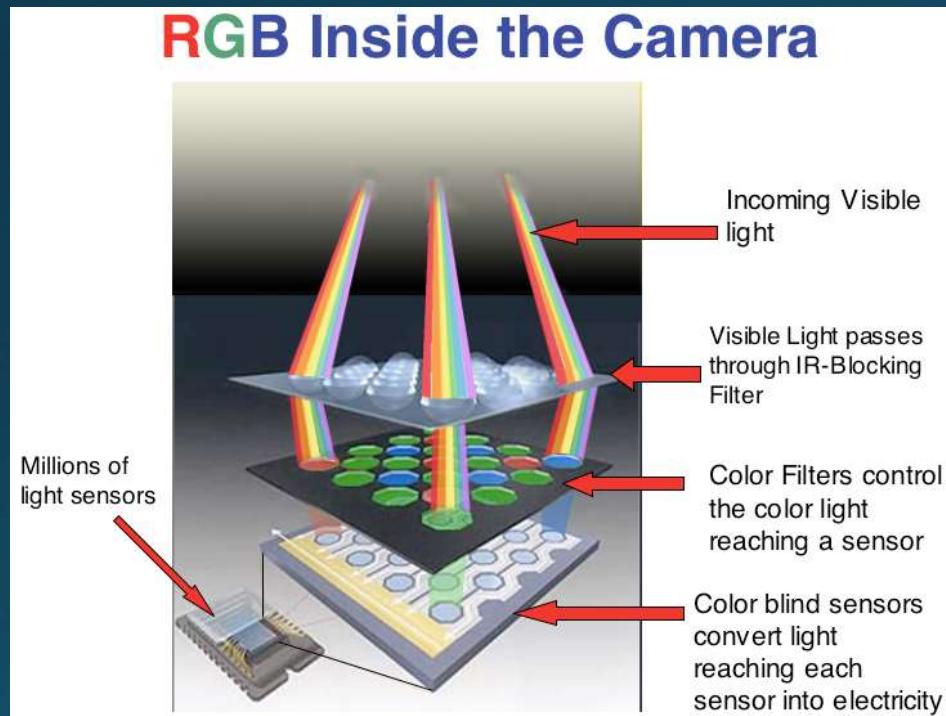
Data sheet

Measurement Performance

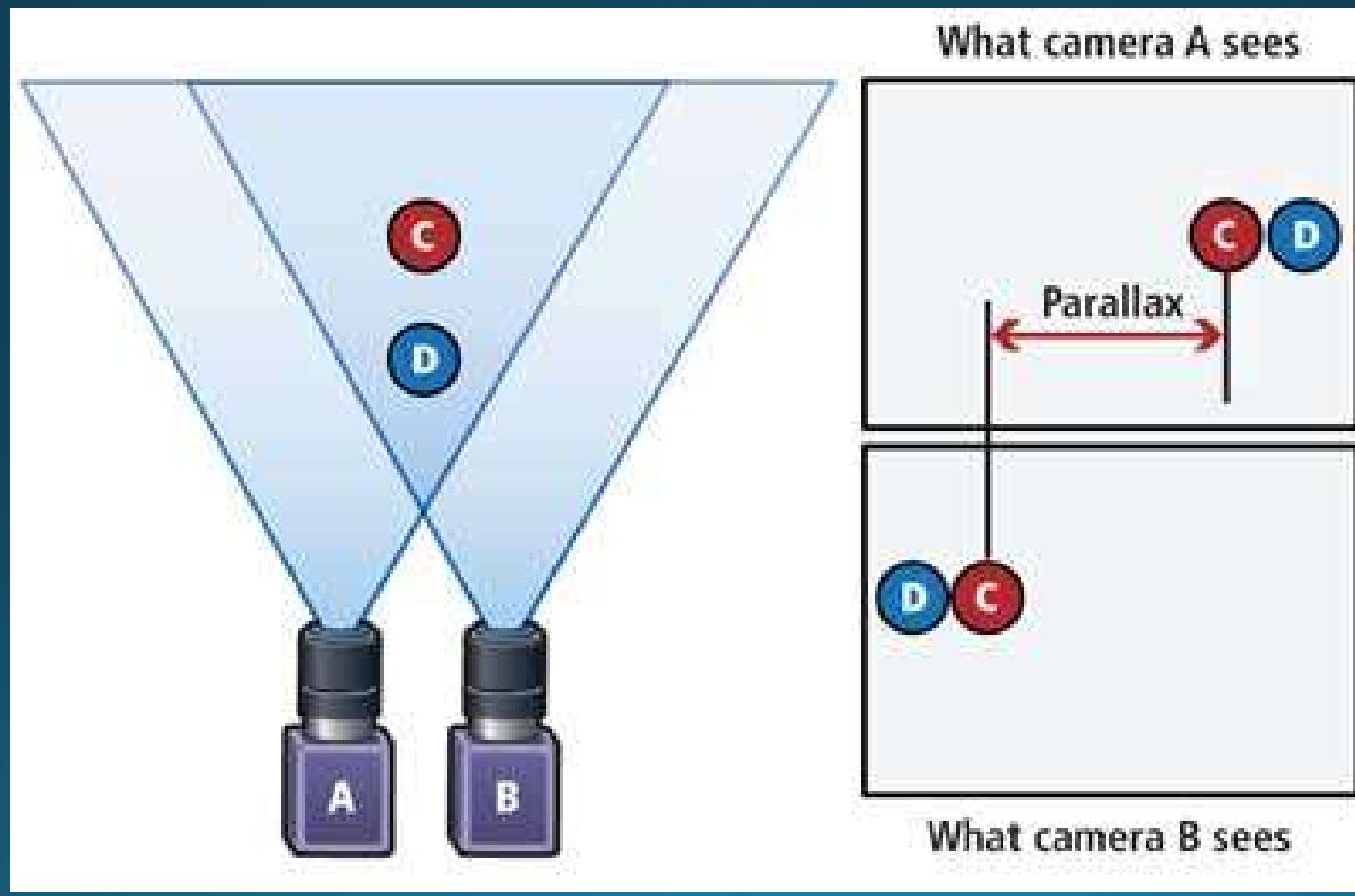
- For Model A1M1 only

Item	Unit	Min	Typical	Max	Comments
Distance Range	Meter(m)	TBD	0.2 - 6	TBD	White objects
Angular Range	Degree	n/a	0-360	n/a	
Distance Resolution	mm	n/a	<0.5 <1% of the distance	n/a	<1.5 meters All distance range*
Angular Resolution	Degree	n/a	□ 1	n/a	5.5Hz scan rate
Sample Duration	Millisecond(ms)	n/a	0.5	n/a	
Sample Frequency	Hz	n/a	□ 2000	2010	
Scan Rate	Hz	1	5.5	10	Typical value is measured when RPLIDAR takes 360 samples per scan

Video cameras: colors and pinhole model



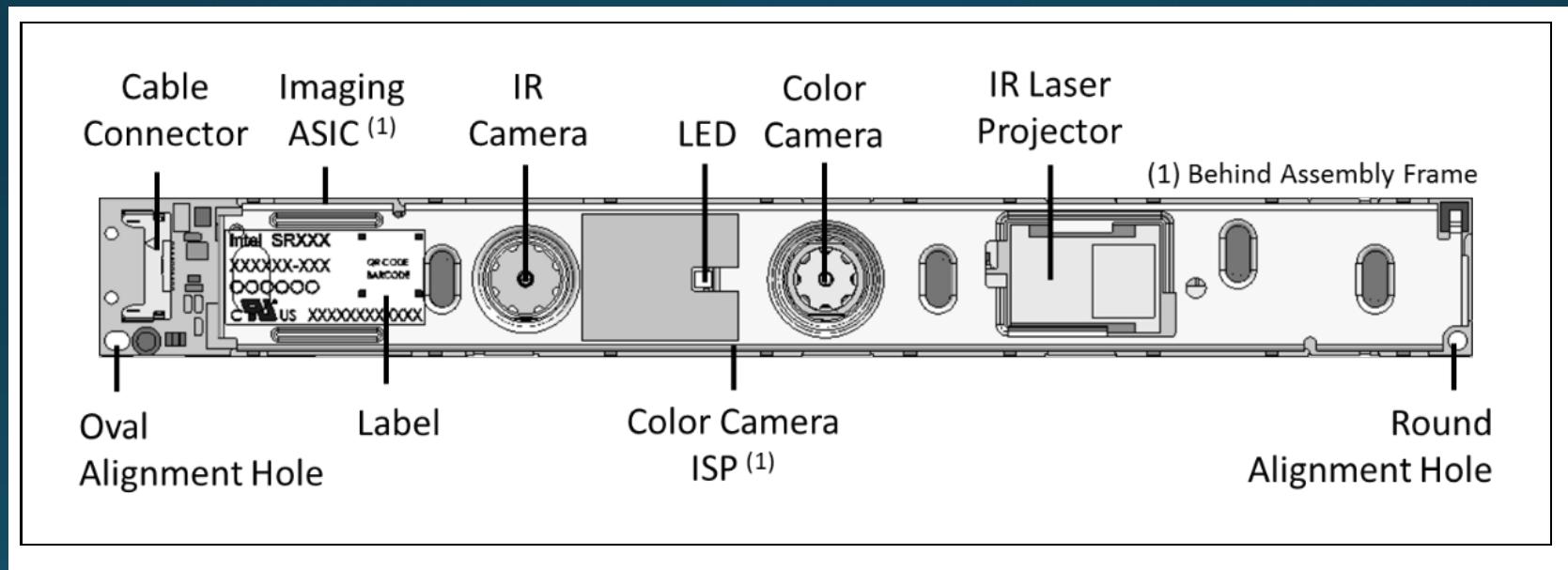
Stereoscopy and Parallax



Structured light for 3D

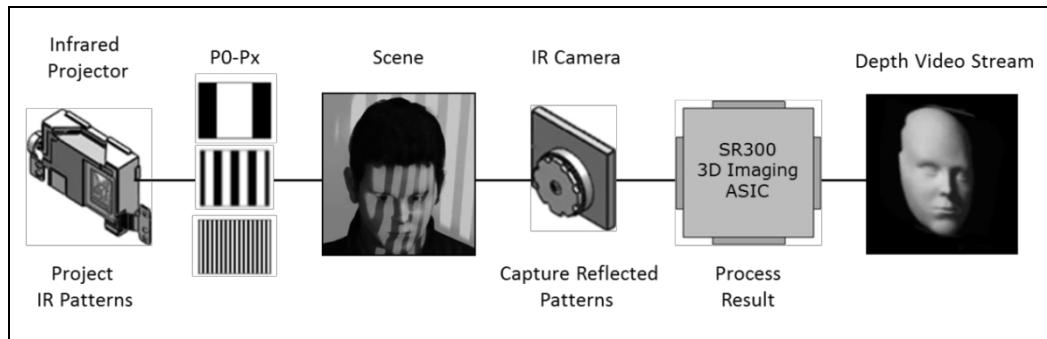


RealSense 3D camera



Principle of operation

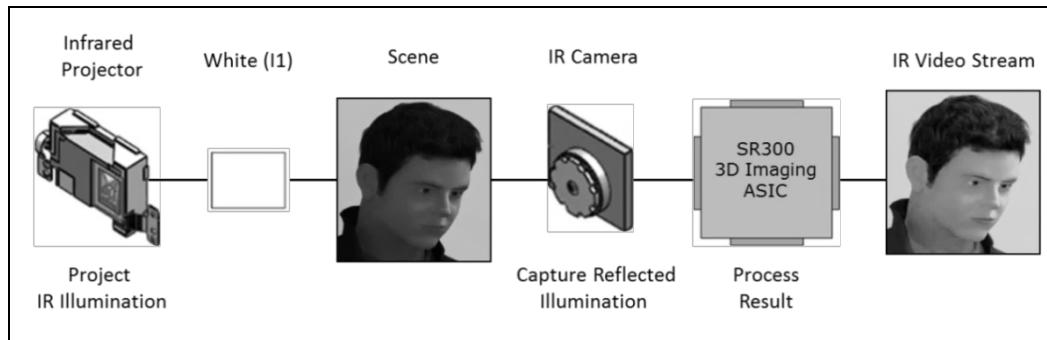
Figure 4-2: Depth Video Data Flow



4.1.2 Infrared Video Data Capture Flow

To generate an IR frame, the IR projector illuminates the scene with a white (I1) pattern. This pattern is reflected by the scene and captured by the IR camera. The IR camera pixel values are processed by the imaging ASIC to generate an IR frame. Subsequent IR frames create a video stream that is transmitted to the client system.

Figure 4-3: IR Video Data Flow



RealSense data

Table 3-1: Infrared and Color Camera Properties

PARAMETER	INFRARED CAMERA	COLOR CAMERA
Active Pixels	640x480	1920x1080
Sensor Aspect Ratio	4:3	16:9
Vertical Field of View	55° +/-2°	41.5° +/-2°
Horizontal Field of View	71.5° +/-2°	68° +/-2°
Diagonal Field of View	88° +/-3°	75.2° +/-4°
Inclination	+/-1° Yaw/Pitch Tilt	+/-1° Yaw/Pitch Tilt

Table 3-2: Infrared Projector Parameters

PARAMETER	DESCRIPTION
Projector	Coded Light
Laser Wavelength	860nm Nominal
Laser Compliance	Class 1, IEC 60825-1:2014 Ed 3
Vertical Field of Projection	60° +/-4°
Horizontal Field of Projection	72.5° +/-2°
Inclination	5°+/-2° Yaw Tilt (Towards IR Camera)

Range

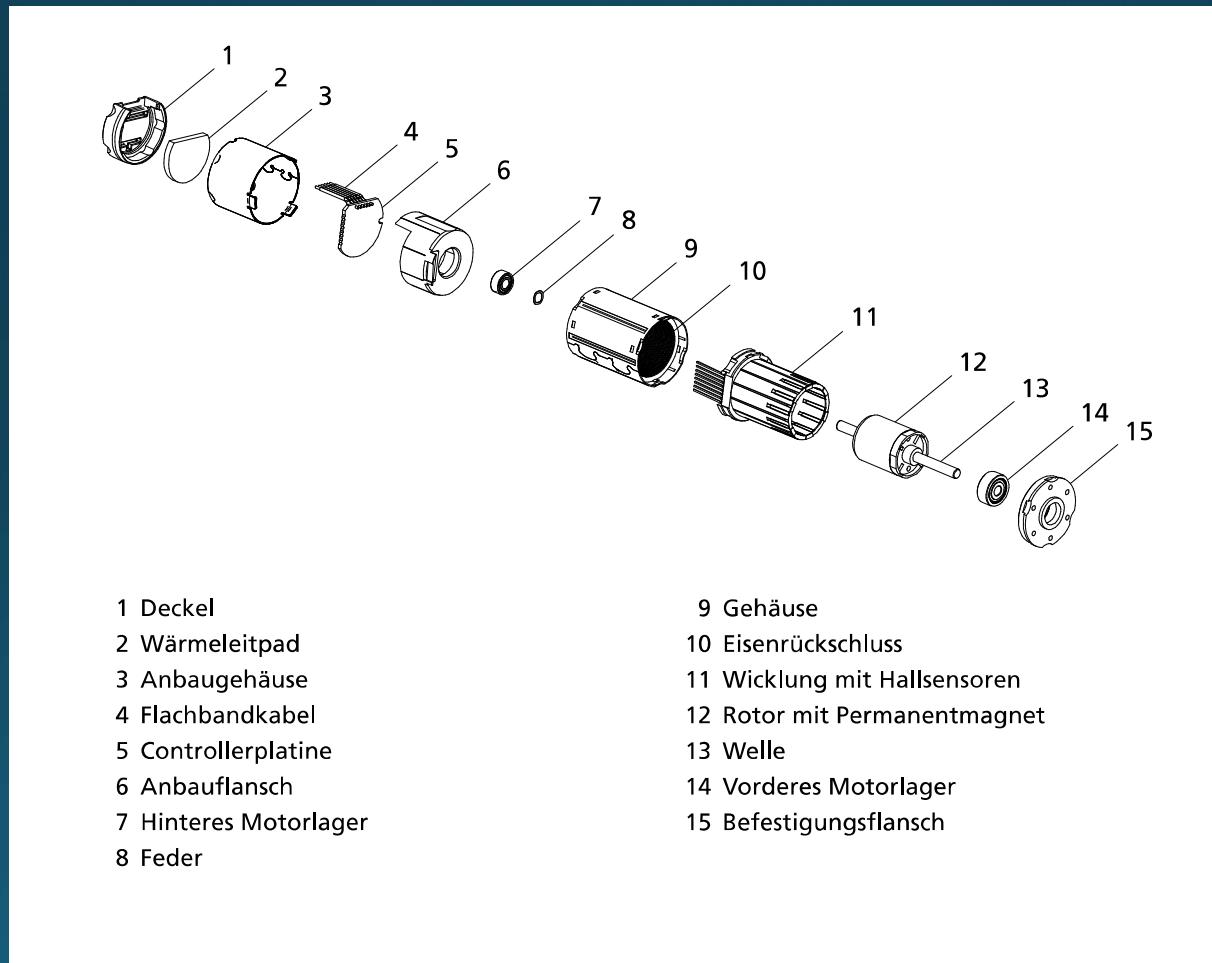
6.1.2 Filter Option Settings

Table 6-4: Filter Properties

PROPERTY	DESCRIPTION	RANGE ⁽¹⁾	VALUE
FILTER_SKELETON	High fidelity pixels only.	up to 4m	0
FILTER_RAW	Raw image with no processing.	up to 4m	1
FILTER_RAW_GRADIENT	Raw image with gradient filter applied.	up to 4m	2
FILTER_SCANNING	Very low smoothing, close range scans.	up to 2m	3
FILTER_LOW_SMOOTH	Low smoothing, high sharpness.	up to 2m	4
FILTER_MED_SMOOTH	Moderate smoothing and sharpness.	up to 2m	5
FILTER_MOTION	High smoothing, object motion.	up to 4m	6
FILTER_BLOB	High smoothing, long range blob.	up to 4m	7

(1) Specifies filter range and not optimized camera range. For depth camera settings which enable objects to be seen further than the optimized camera range, the applicable filter range may apply.

Motors: Faulhaber brushless with speed controller



4.4.1 Anschlussfunktionen

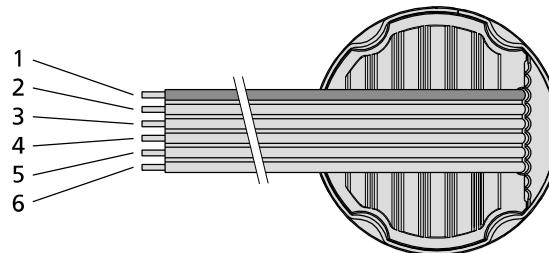
Der Servomotor mit integriertem Speed Controller SC unterstützt folgende Funktionen, bzw. Betriebsmodi:

- Regelung der Drehzahl über Spannung am Sollwerteingang.
- Steuerung der Drehzahl über Spulenspannung.
- Steuerung der Drehrichtung am Schalteingang.
- Auslesen des Drehzahlsignals am Frequenzausgang.

U_P (Ader 1)

Versorgungsspannung für die Elektronik.

Spannungsbereich: 5 ... 28 V DC.



U_{mot} (Ader 2)

Versorgungsspannung für die Motorwicklung.

Spannungsbereich: 6 ... 28 V DC.

Ader	Funktion
1 (rot)	U _P
2	U _{mot}
3	GND
4	U _{soll}
5	DIR
6	FG

GND (Ader 3)

Gemeinsame Masse.

U_{soll} (Ader 4)

Steuerspannung für die Soll-Drehzahl.

Spannungsbereich: 0 ... 10 V DC (für > 10 V DC ... max. U_P ist kein Drehzahlsollwert definiert).

Ist U_{soll} > 10 V DC, wird die Drehzahl auf den 10 V DC entsprechenden Wert geregelt. Dieser Wert liegt oberhalb der Nenndrehzahl, so dass es zur Vollaussteuerung kommt. Wird U_{mot} so weit erhöht, dass die Motoristdrehzahl diesen Sollwert erreicht, wird sie durch die Drehzahlregelung auf den Wert begrenzt, der U_{soll} = 10 V DC entspricht.

Die Eingangsimpedanz dieser Leitung liegt bei $\geq 5 \text{ k}\Omega$.

DIR (Ader 5)

Schalteingang für die Drehrichtung (direction) des Motors.

An Masse oder U < 0,5 V linksdrehend, U > 3 V = rechtsdrehend.

Maximal zulässiger Pegel = U_{Pmax}.

Die Eingangsimpedanz dieser Leitung liegt bei $\geq 10 \text{ k}\Omega$.

FG (Ader 6)

Digitalausgang.

Der Digitalausgang ist ein Schalter, der nach GND schaltet (Open Collector mit integriertem Pull-up-Widerstand von $22\text{ k}\Omega$).

Ausgangsspannung: max. U_P .

Ausgangstrom: max. 15 mA.

Der Digitalausgang kann für verschiedene Aufgaben konfiguriert werden:

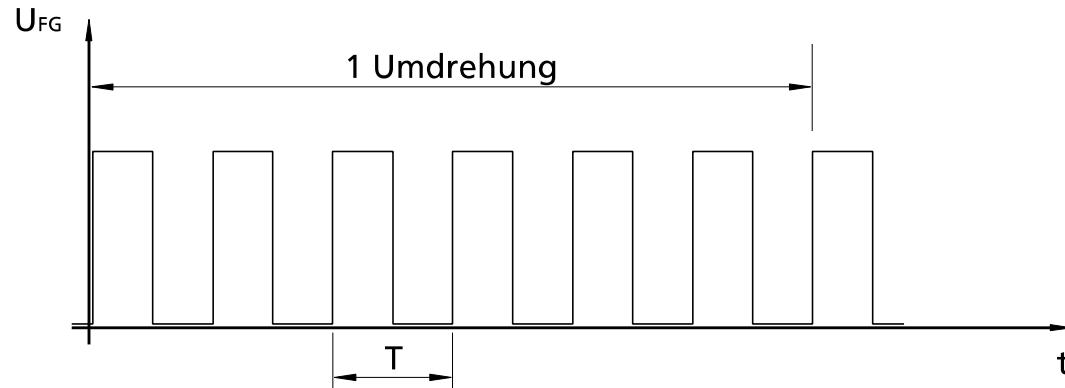
Fehlerausgang

- Ausgang geht auf high Pegel bei Aktivierung der Strombegrenzung. Verzögerung zwischen Aktivierung der Strombegrenzung und Aktivierung des Ausganges ist einstellbar.
- Ausgang geht auf low Pegel bei Deaktivierung der Strombegrenzung.

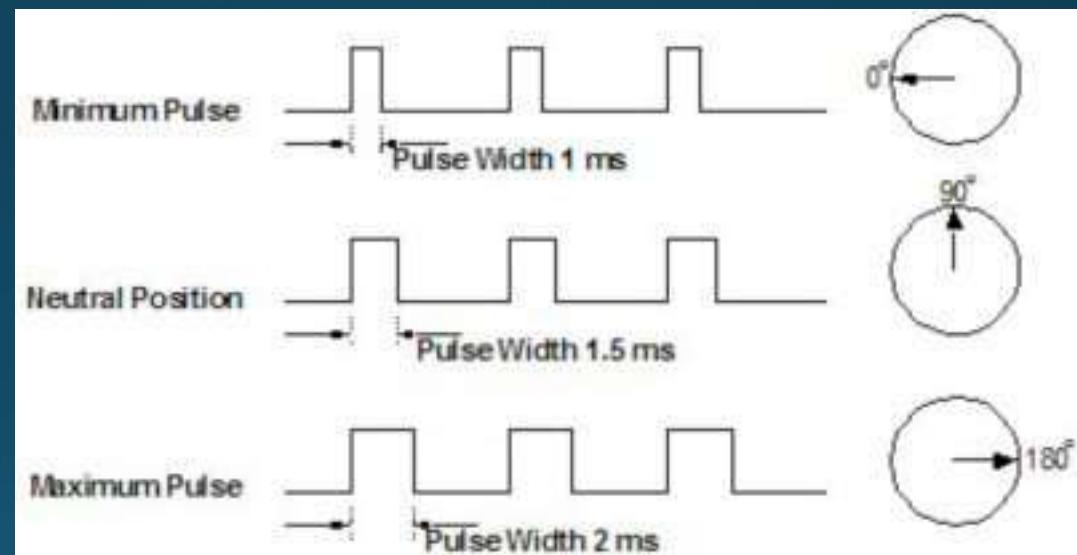
Frequenzausgang

Frequenzausgang zum Auslesen der tatsächlichen Motordrehzahl.

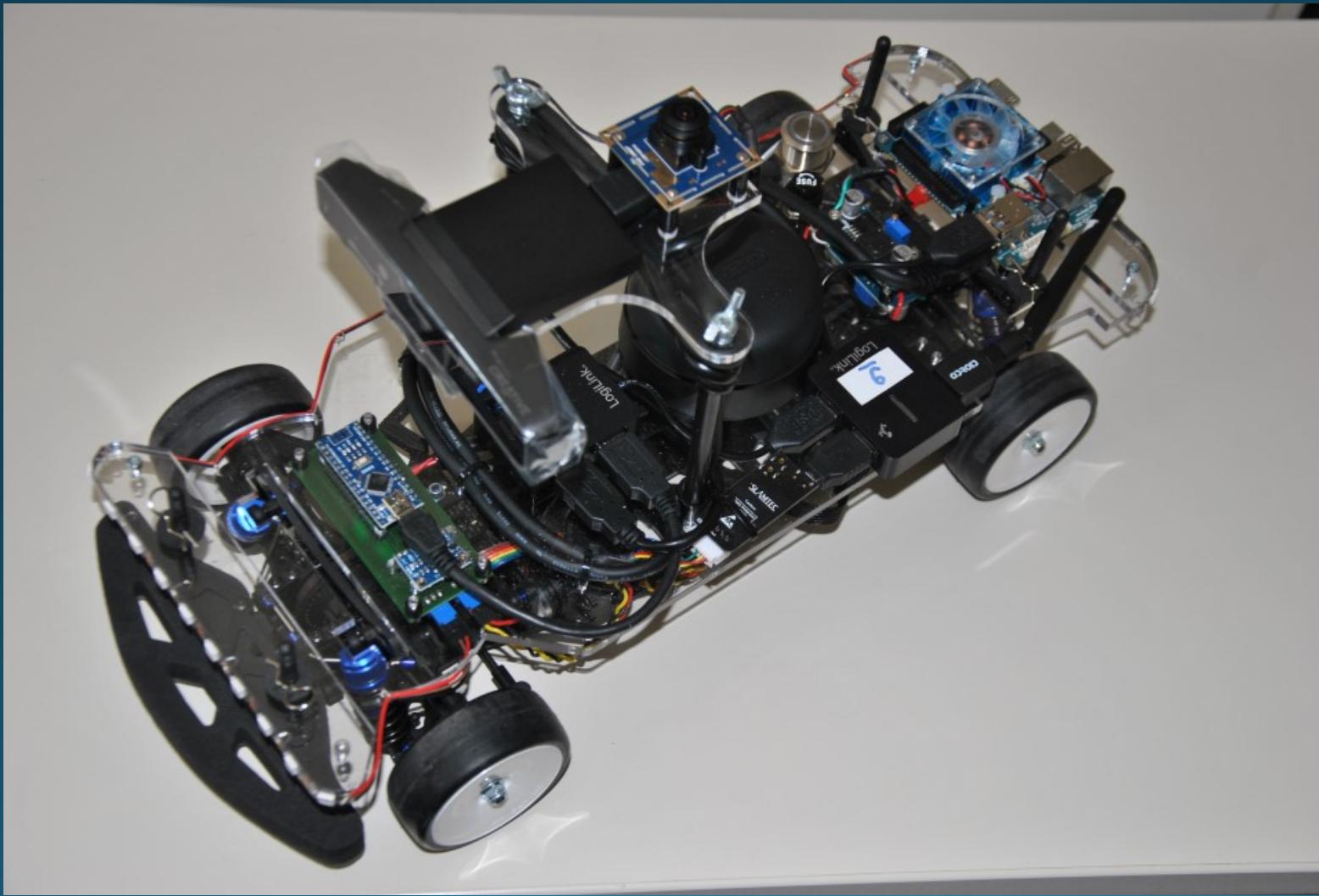
Signalaufbau: 6 Impulse pro Motorumdrehung.



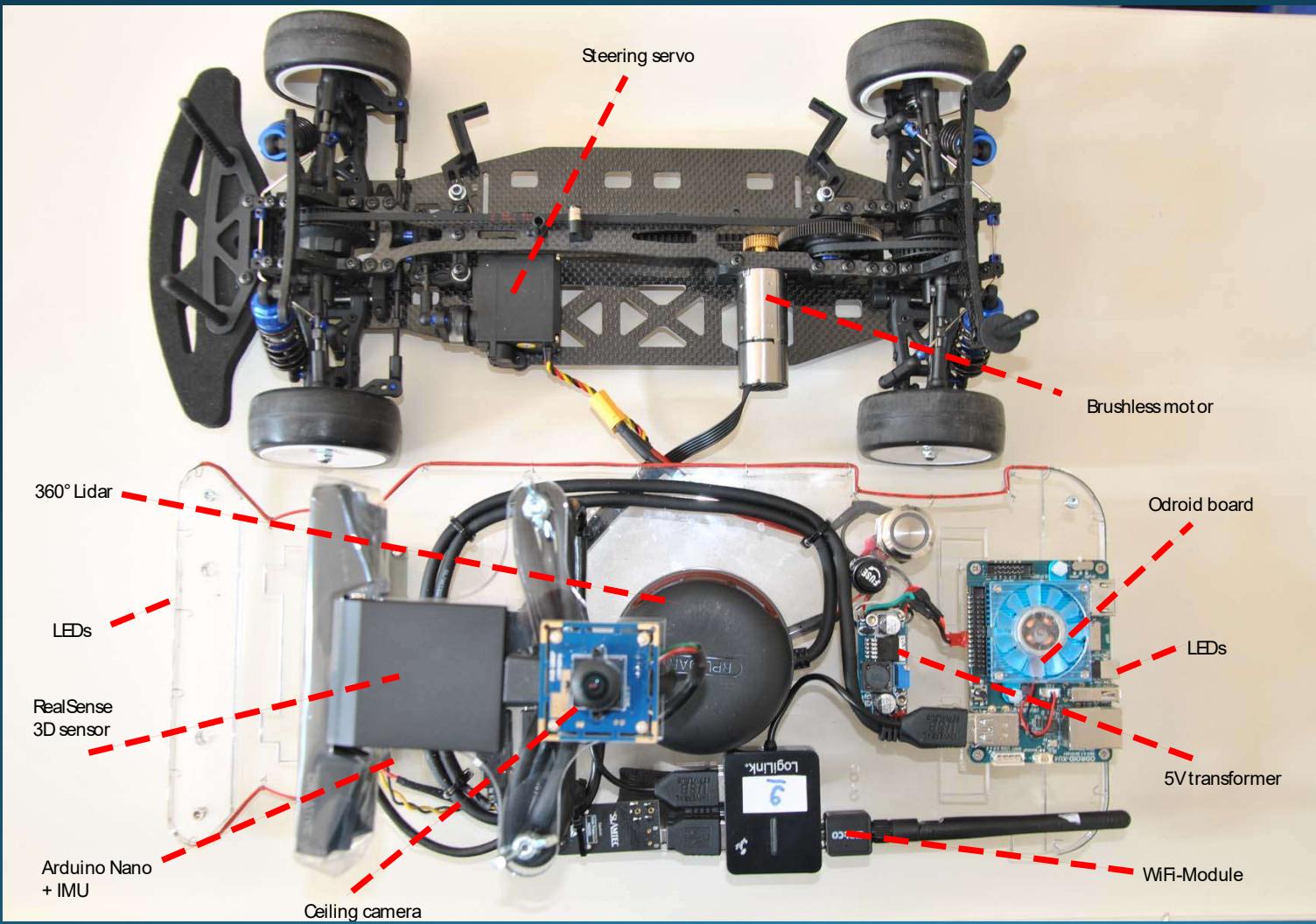
Servo motors



New car

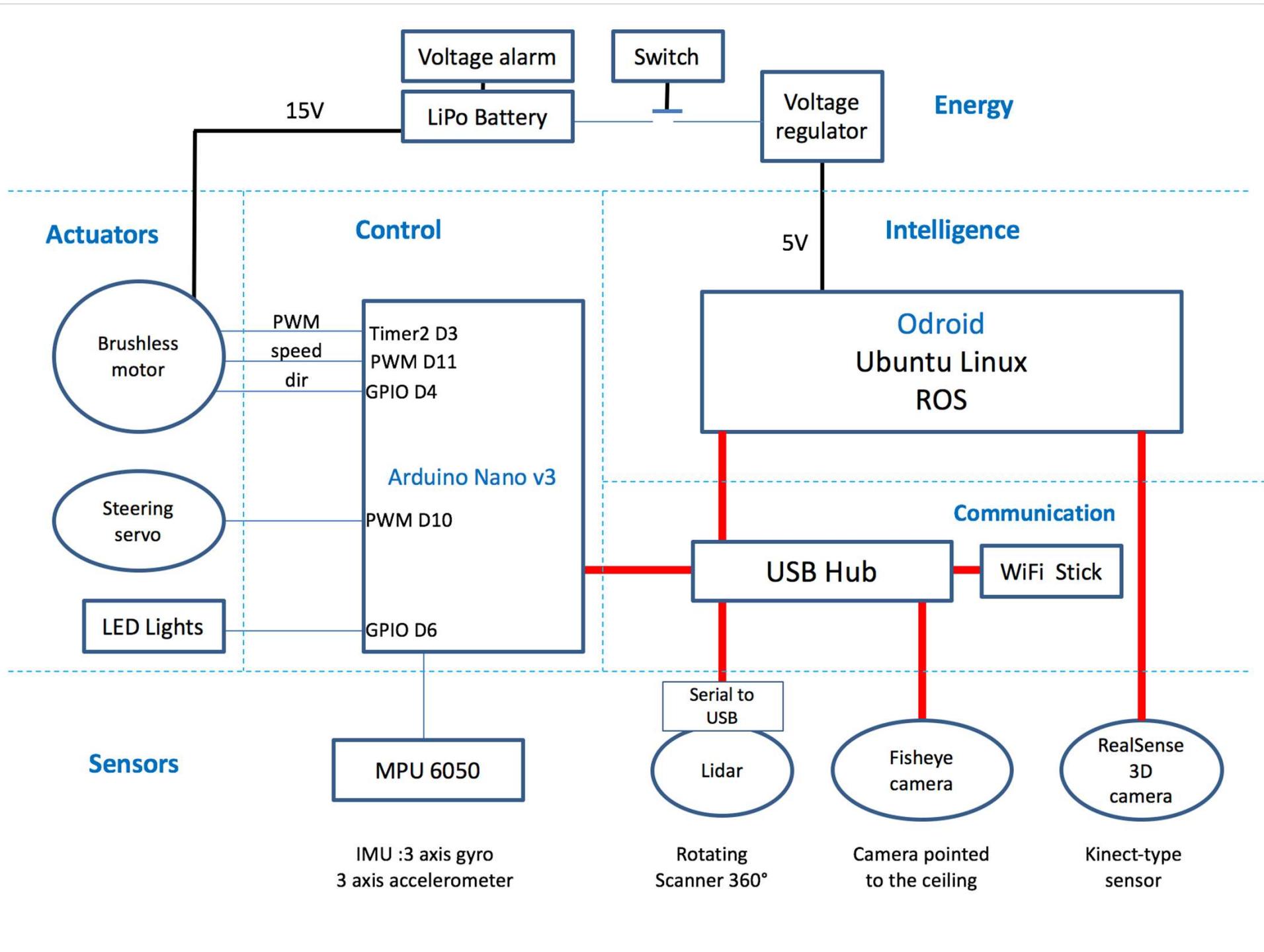


Hardware V3

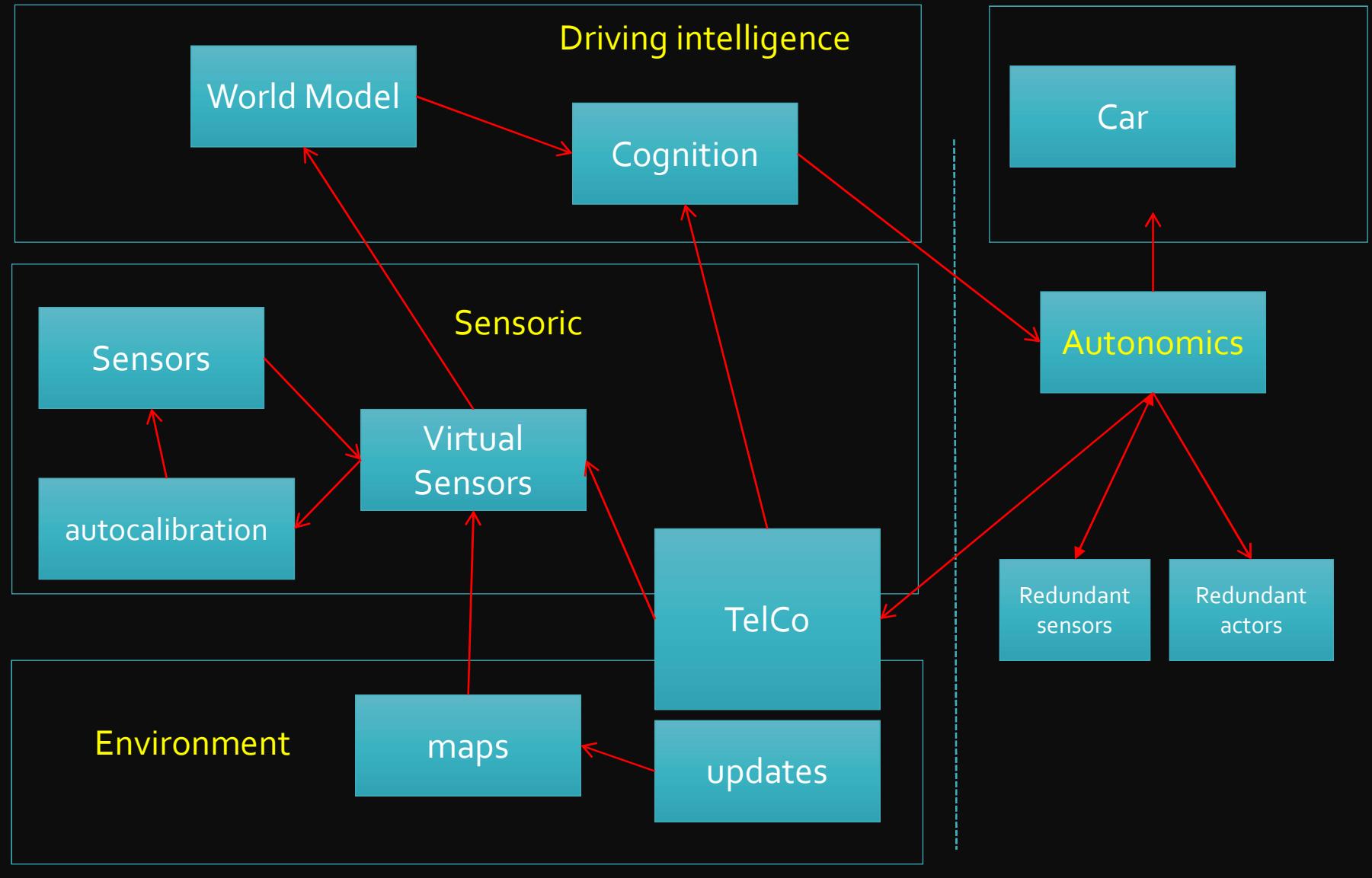


Competition

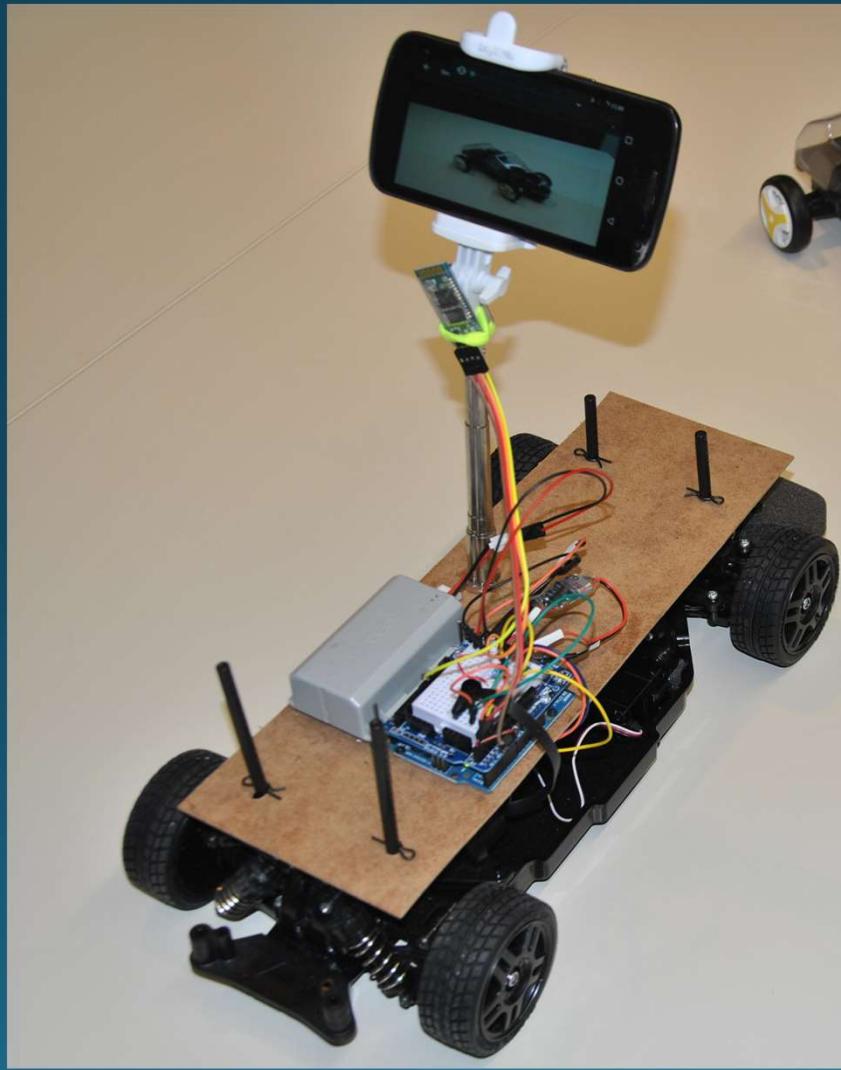




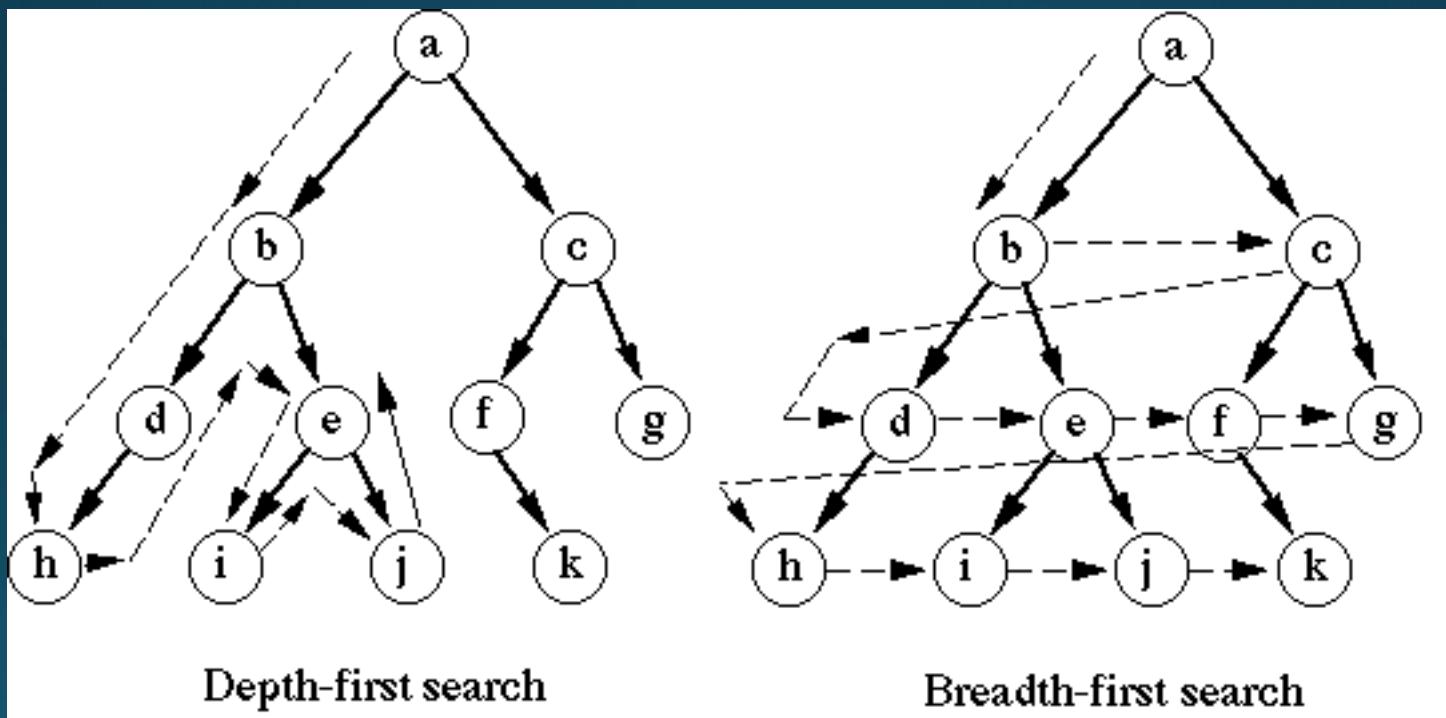
Architecture for Autonomy



Arduino Car

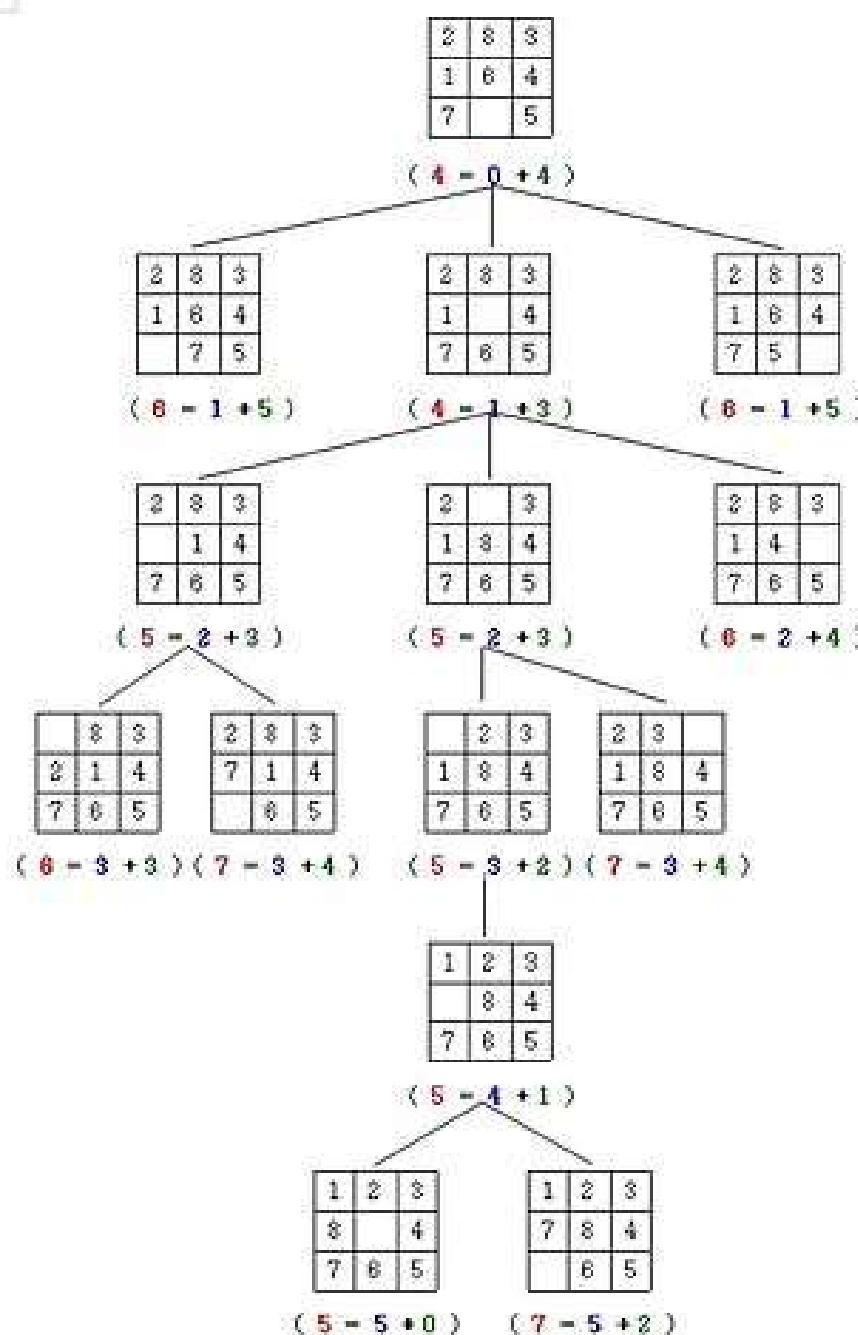


Depth first, breadth first



1	2	3
8		4
7	6	5

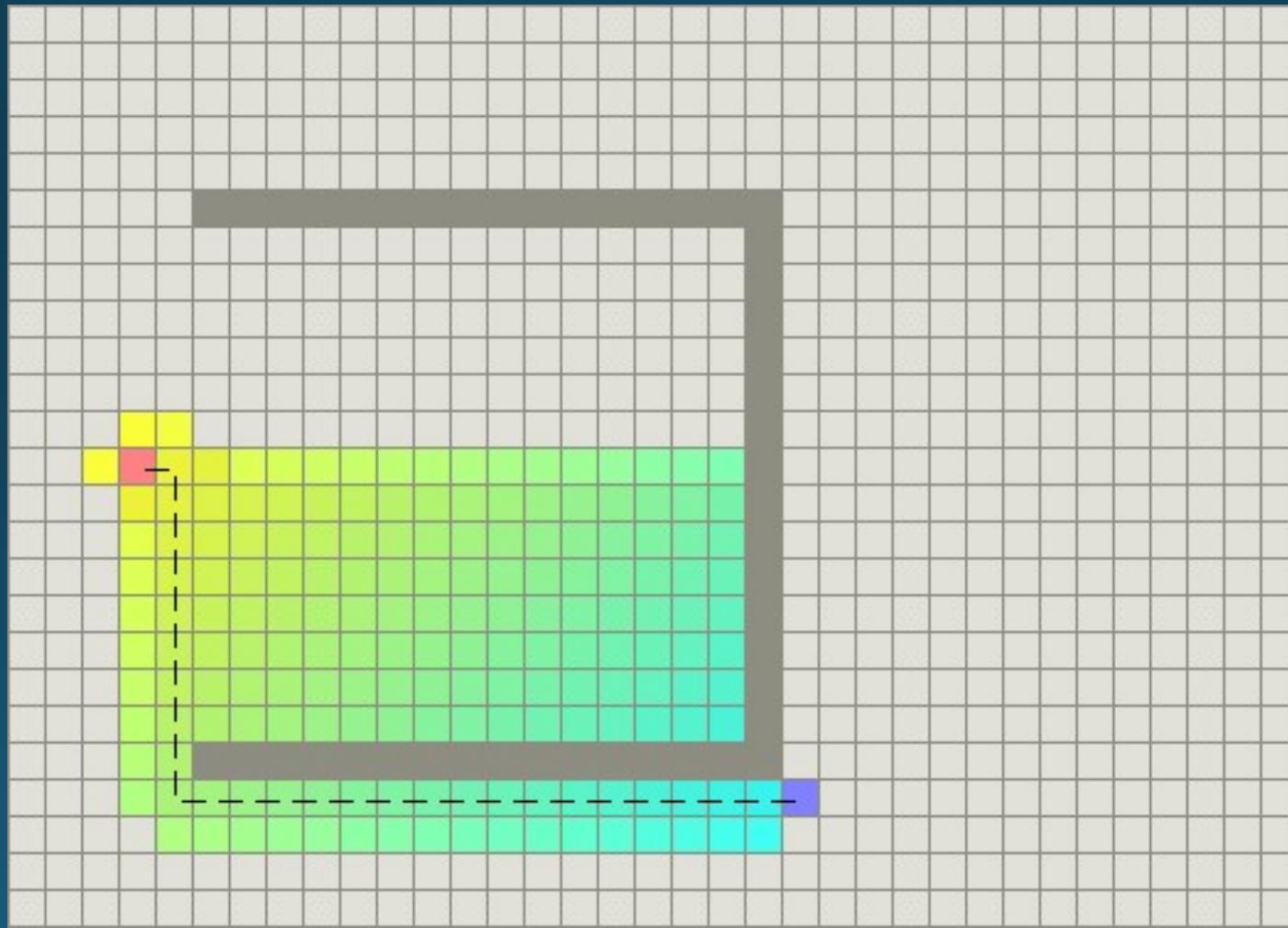
목표 노드



A* path planning

7	6	5	6	7	8	9	10	11		19	20	21	22
6	5	4	5	6	7	8	9	10		18	19	20	21
5	4	3	4	5	6	7	8	9		17	18	19	20
4	3	2	3	4	5	6	7	8		16	17	18	19
3	2	1	2	3	4	5	6	7		15	16	17	18
2	1	0	1	2	3	4	5	6		14	15	16	17
3	2	1	2	3	4	5	6	7		13	14	15	16
4	3	2	3	4	5	6	7	8		12	13	14	15
5	4	3	4	5	6	7	8	9	10	11	12	13	14
6	5	4	5	6	7	8	9	10	11	12	13	14	15

Node expansion



Node expansion

