Robotics with Lego EV3 + Scratch

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Robotics: a very compelling problem setting

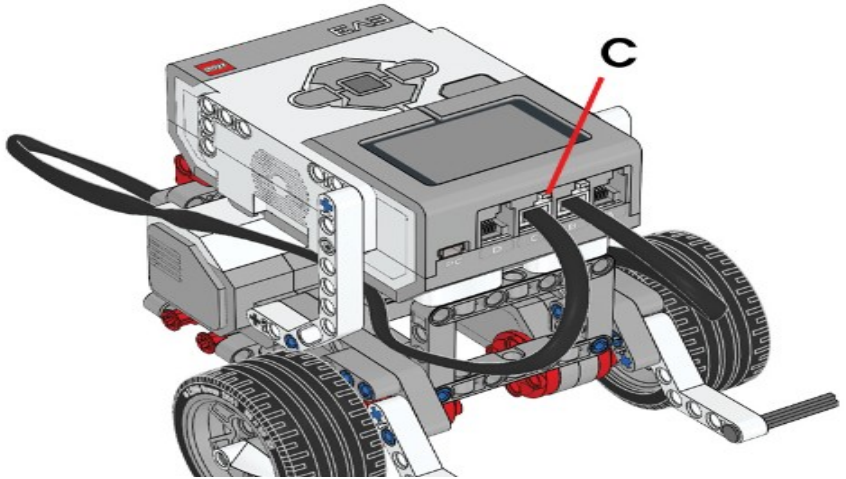
Using robots with kids allows you to:

- **enhance motivation**
- **show concrete evidence of the program's actions**
- **force students to tackle CONCURRENT problems, e.g.:**
- **read sensors WHILE moving**
- **coordinate the movement of many motors (drive/arms)**

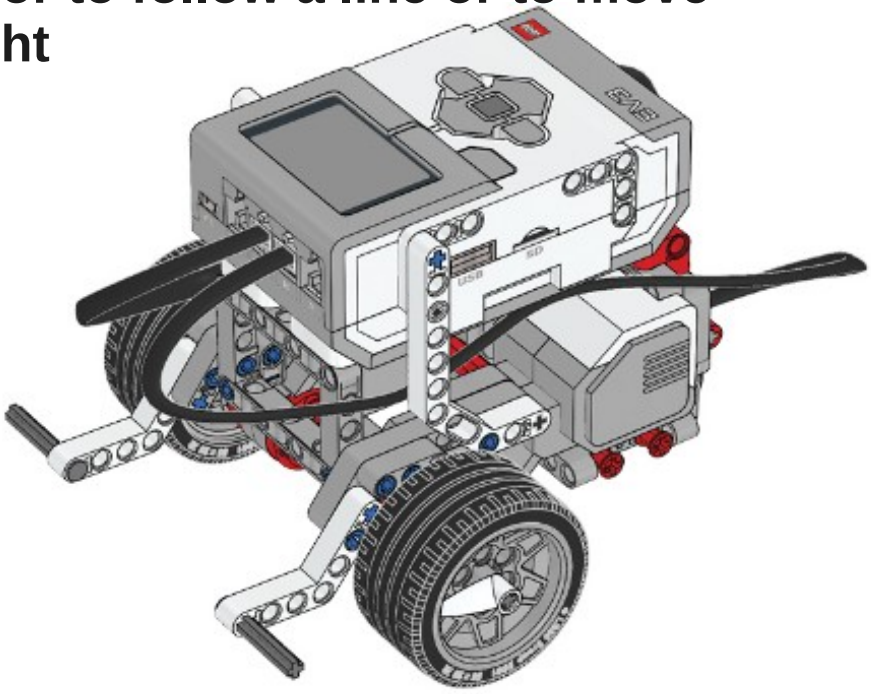
Scratch is VERY limited but, with Lego EV3, sufficient to build:

- **a car moving in a labyrinth**
- **a robotic arm**
- **...**

Lego Mindstorms EV3 kit



To build a <u>differential drive</u> car you need:
- two independently controlled motors
- a distance sensor for front obstacles
- a light sensor to follow a line or to move towards a light



The “brick” has:

- 4 sensor ports (1, 2, 3, 4)
- 4 motor ports (A, B, C, D)
- 2 USB connections (slave + master)
- Bluetooth

Scratch for Lego Mindstorms EV3 or Lego Boost (Windows / MacOs / Chromebook / Android)

Install the Scratch Link driver (Windows or Mac)

Pair the EV3 Bluetooth with the PC

Add the EV3 extension to the Scratch project

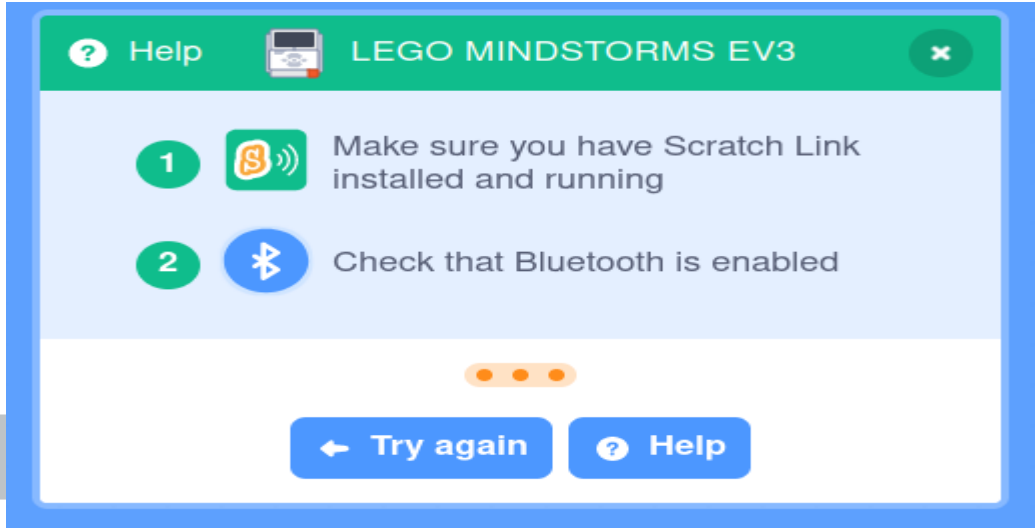
NOTICE: It's added only if the Scratch Link connection is on

If all goes well you can use the EV3 blocks

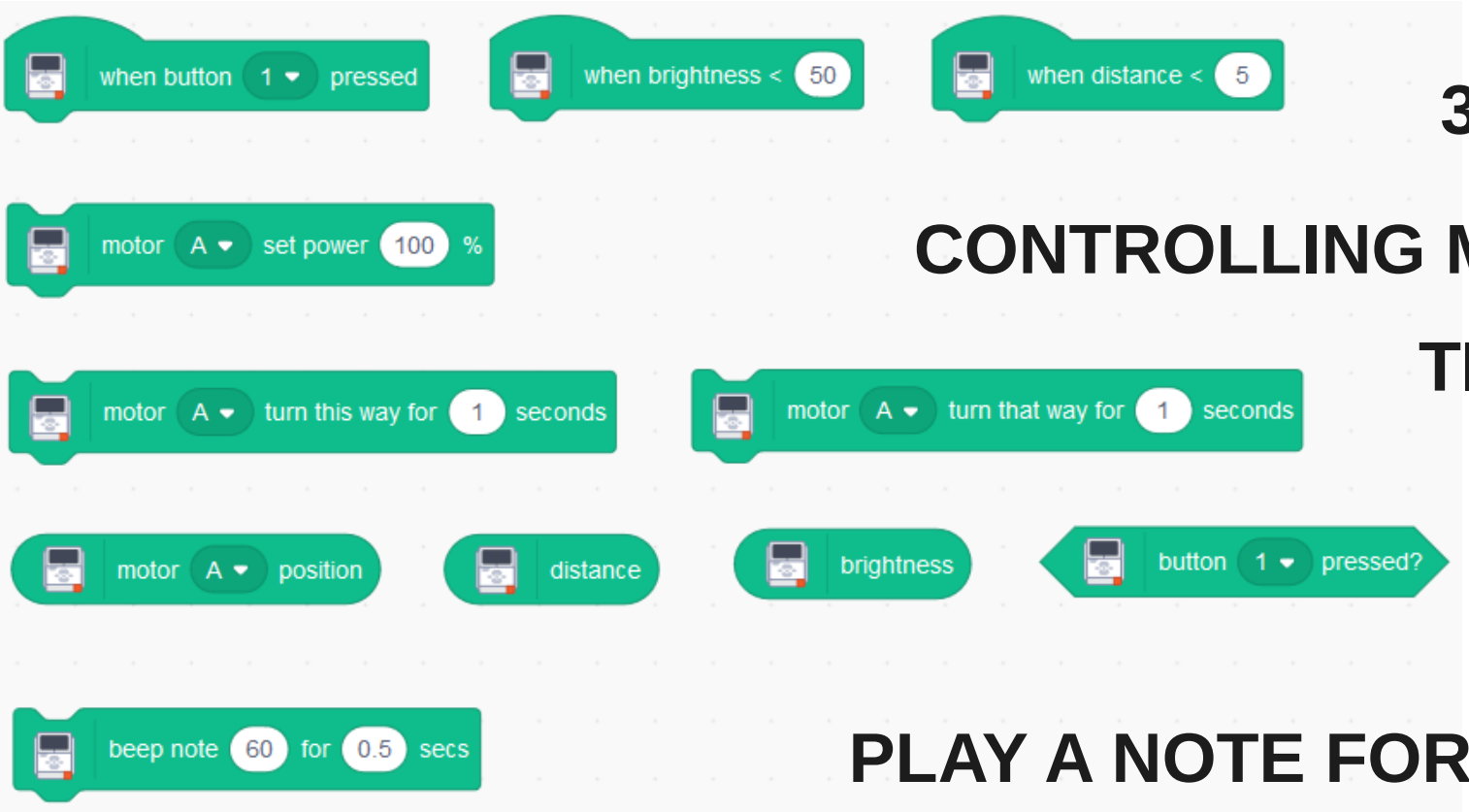
Chromebook/Android do not need

the Scratch Link driver

Linux: not available



Scratch Lego Mindstorms EV3/Boost extensions



3 NEW EVENTS

CONTROLLING MOTOR SPEED

TIMED MOTORS

4 TYPES

OF SENSORS

PLAY A NOTE FOR A GIVEN TIME

LIMITS of Lego EV3 Scratch extension: SENSORS

You can use ONLY ONE sensor for:

- **DISTANCE (Ultrasound sensor)**
- **DISTANCE IN INCHES???** **(ask the student to convert to cm if needed)**
- **BRIGHTNESS (Light/colour sensor)**
  - **VERY LOW VALUES!!!** **(difficult to use)**

The BUTTON-PRESSED event is somewhat erratic (use polling instead)

The DISTANCE-LESS-THAN event works way better

The LIGHT-LESS-THAN event seems not to work!!! **(!"$$"£!$!)**

NOTICE:

the program runs in the browser and interacts with EV3 by Bluetooth

LIMITS of Lego EV3 Scratch extension: MOTORS

You can use UP TO 4

- motors on the A, B, C, D ports

- touch sensors on ports 1, 2, 3, 4

BUT: CANNOT rotate one motor for a given angle (ONLY TIMED run)

- Calibration is very important (e.g. time vs distance)

MOTOR POSITION SEEMS NOT TO WORK WELL (!$”$!”£|!$£|!)

OTHER:

- BLUETOOTH IS “BLOODY TRICKY” … (!|$!%£$!”%!”)

CONCURRENCY for Robotics in Scratch

Concurrency is a good reason to use Scratch

WHY? You must coordinate:

- **many motors (at least 2 for differential movement)**
- **reading many sensors**

You can define multiple threads for the same event/MESSAGE

- **unfortunately, messages DO NOT carry arguments**
- **(HACK: use global variables)**

Choose a simple parametrization of single movements and JOIN

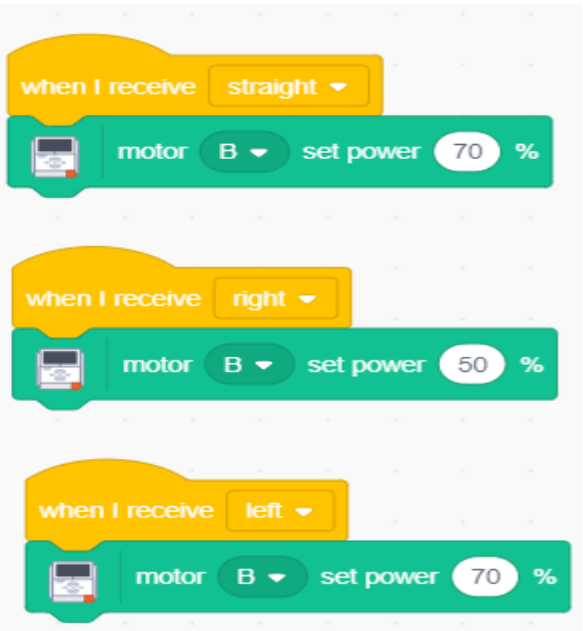
- **time, speed, direction for each motor**
- **to get forward/backward, curves**

Example: Line Follower coordinating two motors with messages

Using messages to coordinate concurrent actions on both motors

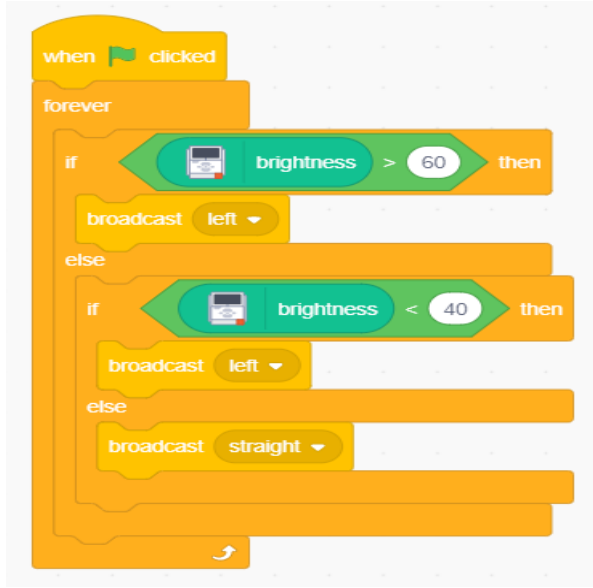
MOTOR A

MOTOR B



CONTROLLER

Stay on the line border where reflected light is about 50%



Robots and Concurrency:
New interesting factors to take into cosideration

CALIBRATION:

You must calibrate movements and sensors values

CONCURRENCY:

Consider the possible compositions of concurrent actions

(and add semaphores to exclude incompatible actions)

(and remember to unlock semaphores)

Decide if an action should be Blocking/Non-blocking

i.e. if you must wait or not for message completion