Sensors and Electronics

Introduction to Sensors

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Introduction to Sensors

- A sensor is a device that collects information from the “real world” by detecting or measuring a signal or stimulus that occurs from a change in its nearby environment.
- “A device which provides a usable output in response to a specified measurand”

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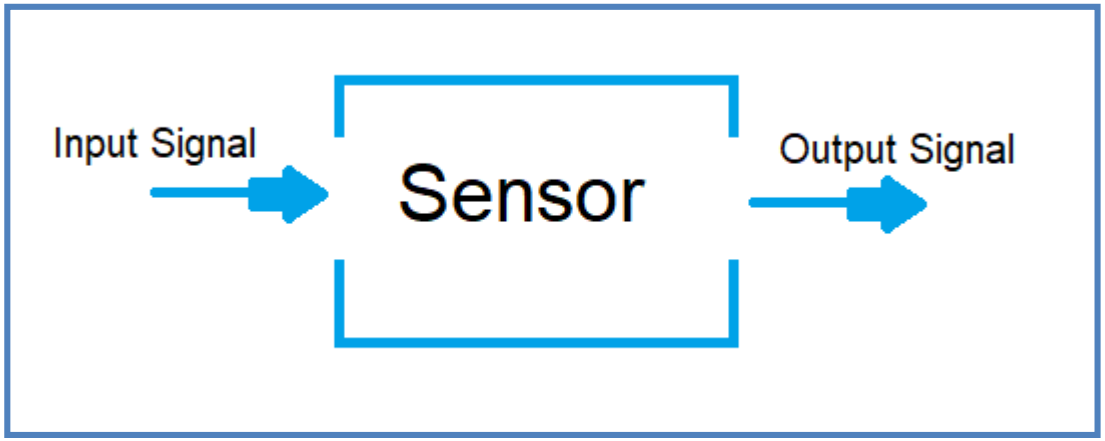
Introduction to Sensors

- Sensors measure a physical parameter (input) and convert it into a signal suitable for processing (output).



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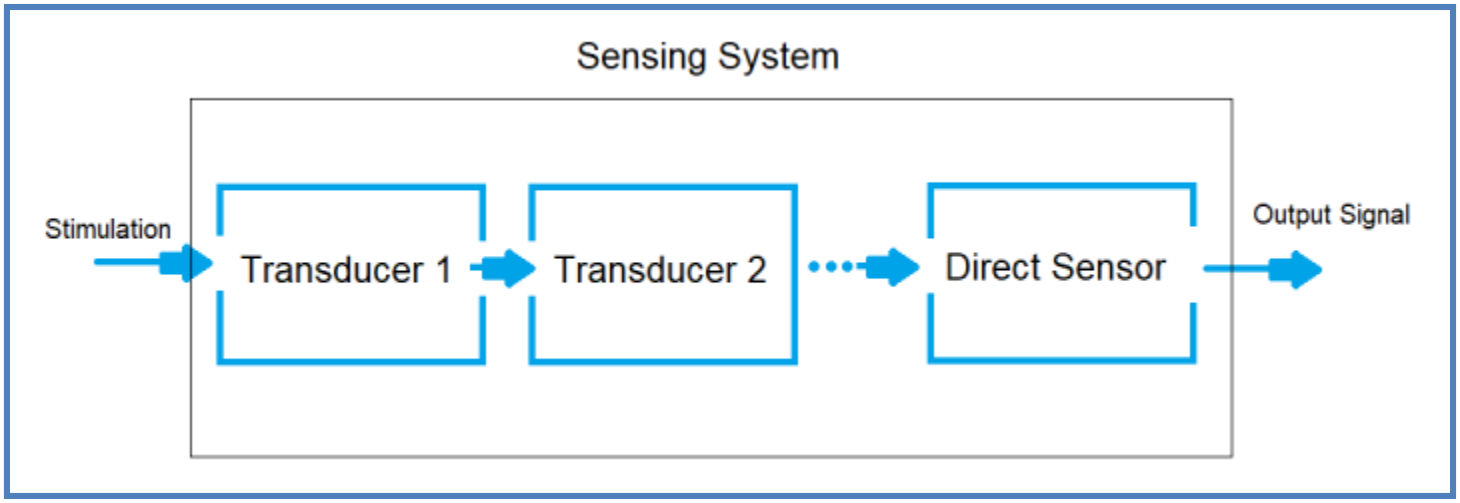
Introduction to Sensors

- Therefore, sensors are devices that receive a stimulus and respond with an electrical signal depending on the stimulation.
- All sensors are based on a transduction principle - conversion of energy from one form to another.

Introduction to Sensors

- A transducer is required for the sensing system to convert the stimulation from the environment into electrical signal.



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Sensor Types

- There are two types of sensors based on their ability to convert non-electrical stimulus into an electrical signal.
- Direct Sensors
  - can convert a non-electrical stimulus into an electrical signal with intermediate stages.
- Indirect or Complex Sensors
  - multiple conversion steps are used to transform the measured signal into an electrical signal.

Sensor Types

- Another way to categorize sensors is based on whether they use their own source of energy to "sense" their nearby environment.
- Active Sensors
  - Use energy to send a signal into the environment and measure the interaction of said signal with the environment.
- Passive Sensors
  - record signals already present in environment.

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Sensor Types

- An example of an **active sensor** would be an ultrasonic sensor that emits sound waves to the environment and based on what is returned to the system, it can generate a model of the surface that is in front of it.
  - An agricultural application would be the use of an ultrasonic sensor to generate a 3d model of the canopy to optimize spraying applications, i.e. apply more or less agrochemicals based on the canopy density of the crops.

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Sensor Types

- **Passive sensors** are a major part of remote sensing in agriculture, and all principles will be thoroughly covered in the next lesson. However for now, you can think a very easy example: Our eyes.
  - Our vision is based on our eyes' (sensors) ability to sense the environment by receiving light that is reflected from other bodies - we do not send energy to the target in order to see, we just receive what is reflected towards us.

Sensor Characteristics

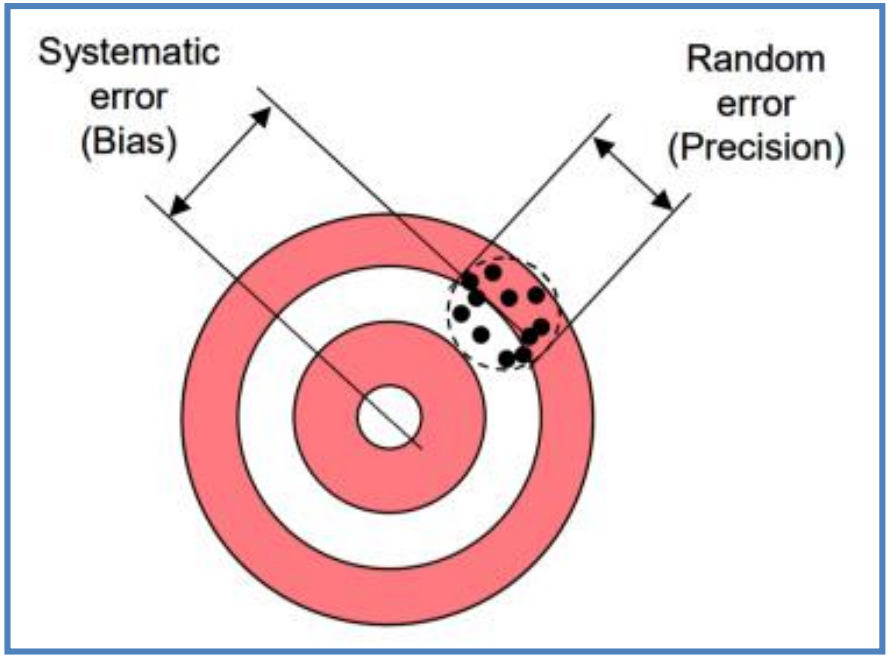
- **Accuracy** is the capacity of a sensor to give **results** close to the **true value** of the measured quantity. Accuracy is related to the bias of a set of measurements and is measured by the absolute and relative errors.

$$\text{ABSOLUTE ERROR} = \text{RESULT} - \text{TRUE VALUE}$$

$$\text{RELATIVE ERROR} = \frac{\text{ABSOLUTE ERROR}}{\text{TRUE VALUE}}$$

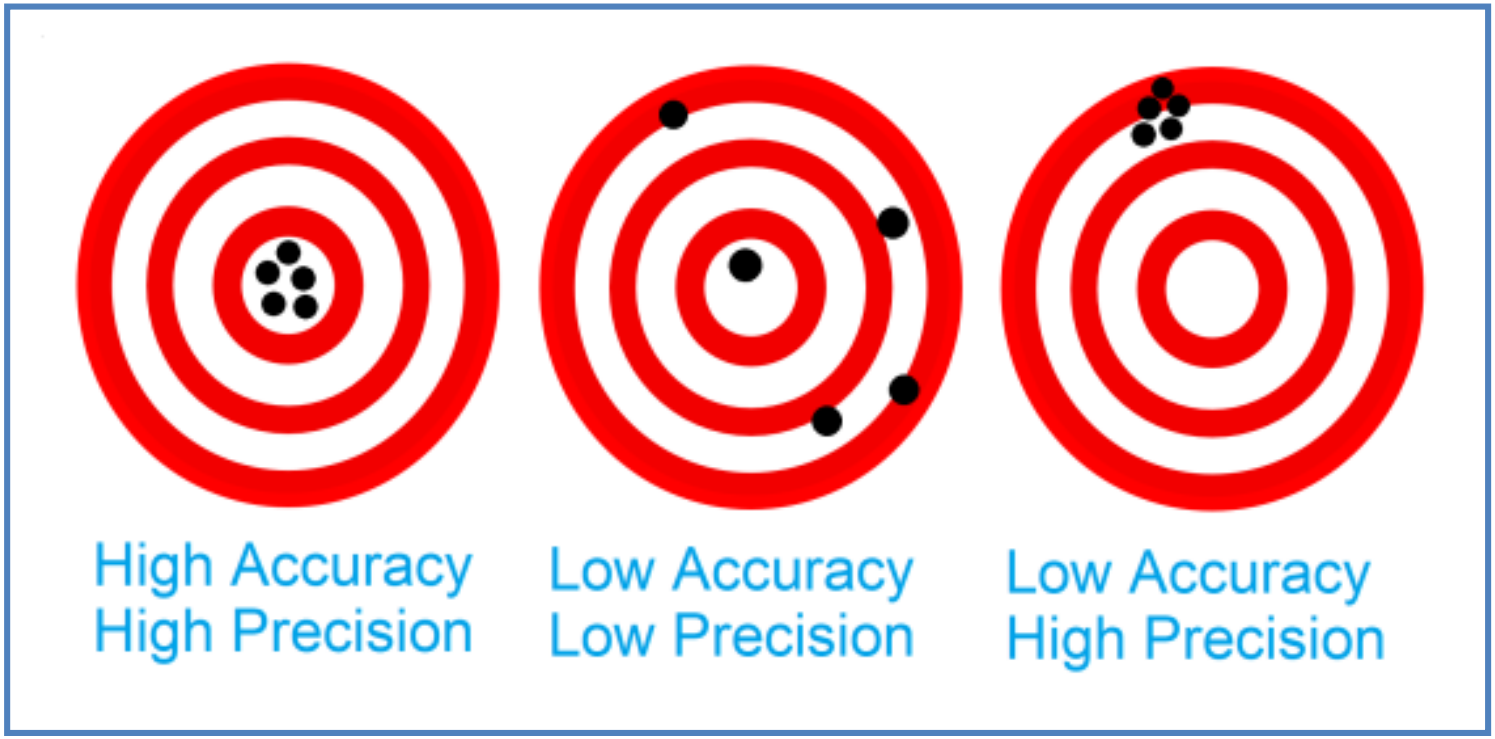
Sensor Characteristics

- **Precision** is the ability of a sensing system to give the same reading when repetitively performing the exact same measurement under the same conditions.
- It implies consistency among successive readings, but not the accuracy of the system. Although a necessary factor, it is not a sufficient condition for accuracy by itself.



Source: Ricardo Gutierrez-Osuna, Wright State University

Sensor Characteristics



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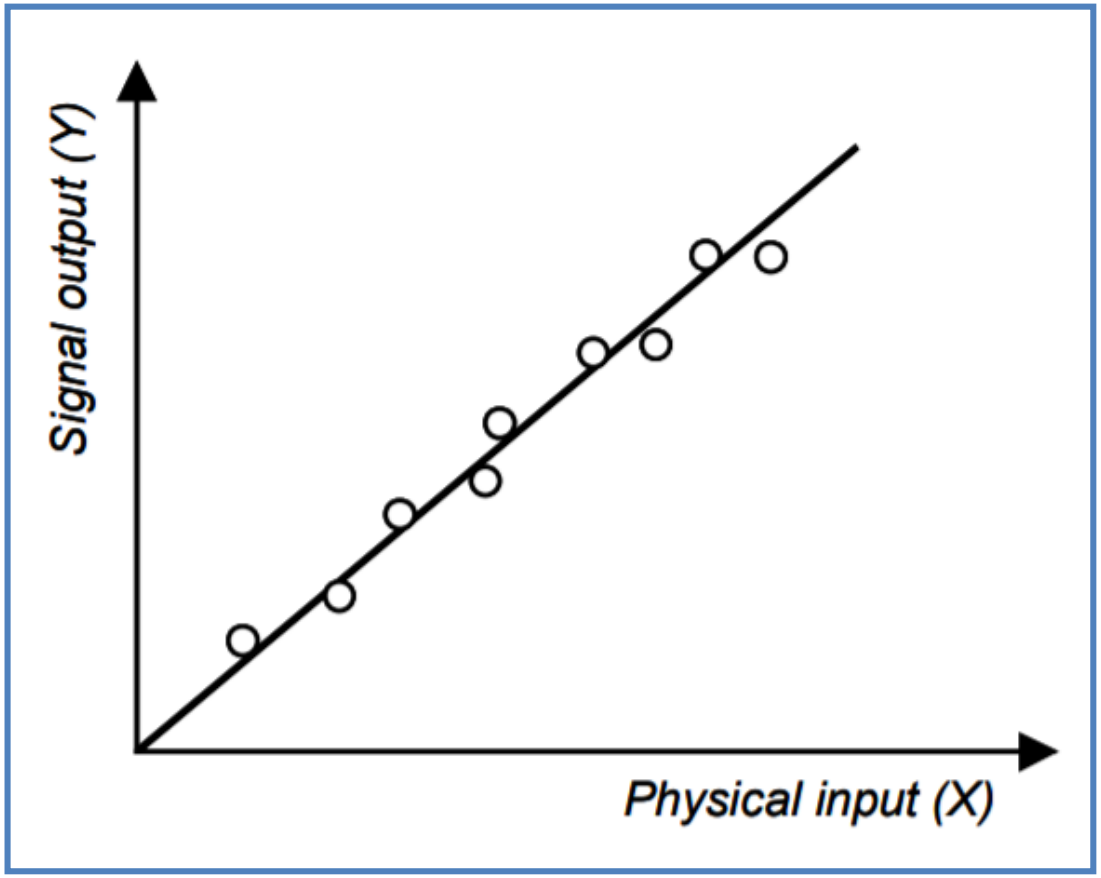
Sensor Characteristics

- **Resolution** or Discrimination is the minimal change of the input necessary to produce a detectable change at the output.
- **Repeatability** is the precision of a set of measurements taken over a short time interval.
- **Reproducibility** is the precision of a set of measurements but under certain conditions (taken over a long time interval or measurements taking place in different laboratories).

Sensor Calibration

- The relationship between the physical measurement variable (X) and the signal variable (Y).
- A sensor or instrument is calibrated by applying a number of known physical inputs and recording the response of the system.
  - Calibration Curve

Sensor Calibration



Source: Ricardo Gutierrez-Osuna,
Wright State University

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Spatial Sensor Data

- So far we have seen that measurements of a parameter are generated by sensors, after they transform stimulations from the environment to electrical signal.
- The output of the sensor is essentially a quantification of measured parameter, and with the use of appropriate mathematical functions, it can be translated to data.

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Spatial Sensor Data

- The electrical signal can therefore be translated into data values that represent data of the attribute that the sensor measures.
- Data is either stored inside the system (internal memory), sent to another platform via a wireless network, or returned to us in real time with the user interface (reading on the instruments screen).

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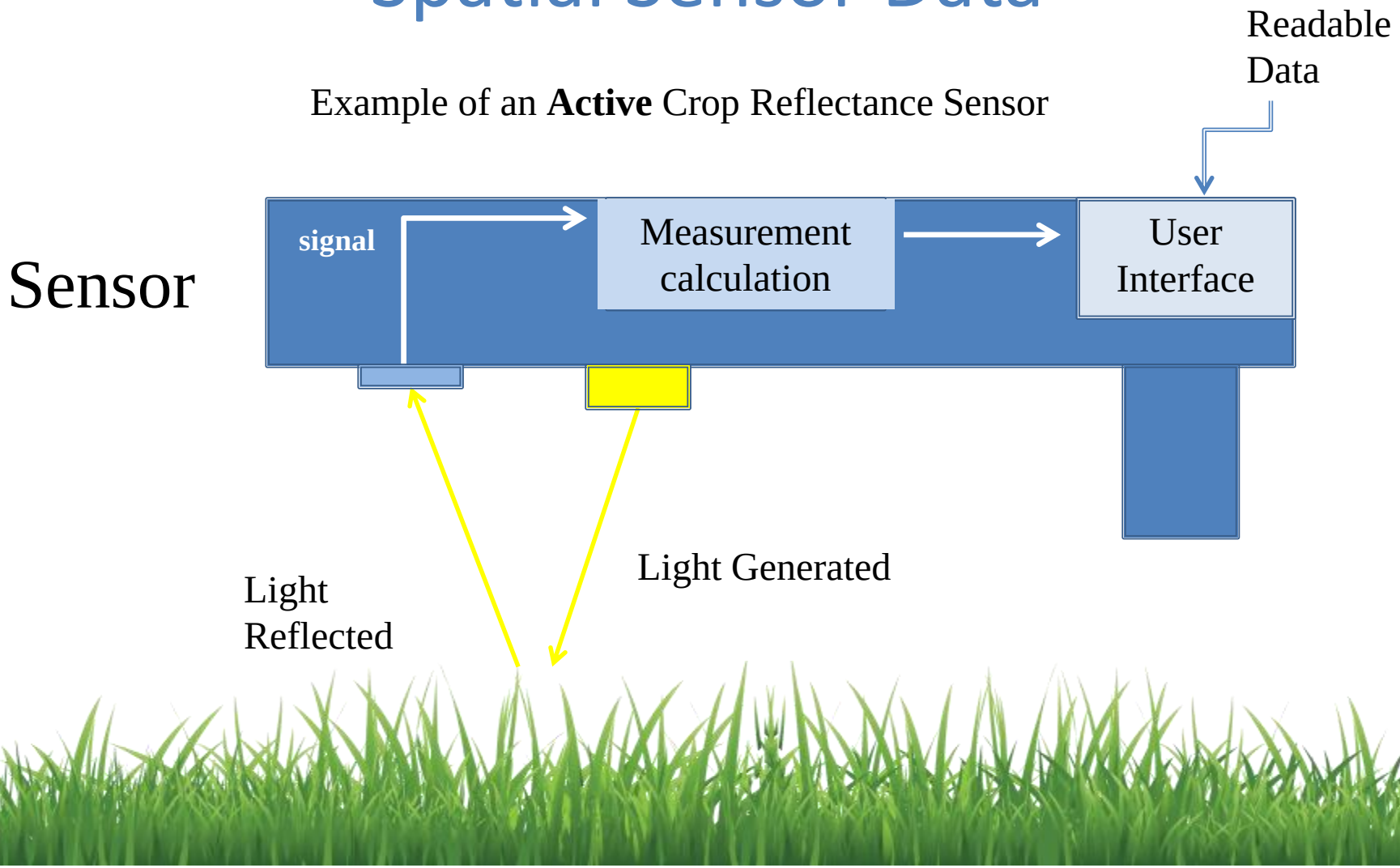
Spatial Sensor Data

Example of an **Active** Crop Reflectance Sensor



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Spatial Sensor Data

- By combining a measuring instrument with a Positioning System (GPS), each data point can be **geo-located**, which means each data point is bounded with the corresponding position of the real world where the data was collected.

Spatial Sensor Data

Georeferenced data that represent single points in the real world, where each measurement corresponds

	A	B	C	D	E
1	Longitude	Latitude	CV1m	CV0.5m	Elevation
2	22.74432033	39.48851333	63.023	40.607	53.1
3	22.74432033	39.48851333	61.617	40.373	53.1
4	22.74432033	39.48851333	61.265	40.216	53.1
5	22.74432033	39.48851333	61.539	40.294	53.1
6	22.74432033	39.48851333	62.203	40.451	53.1
7	22.74432033	39.48851333	62.008	40.373	53.1
8	22.74432033	39.48851333	61.968	40.607	53.1
9	22.74432033	39.48851333	61.734	40.451	53.1
10	22.74432033	39.48851333	61.89	40.216	53.1
11	22.74432033	39.48851333	61.461	40.333	53.1
12	22.74432033	39.48851333	61.461	40.294	53.1
13	22.74432033	39.48851333	62.008	40.255	53.1
14	22.74432033	39.48851333	61.187	40.373	53.1
15	22.74432033	39.48851333	61.929	40.255	53.1
16	22.74432033	39.48851333	61.343	40.255	53.1
17	22.74432033	39.48851333	60.523	39.669	53.1

Data Values of measured parameters

DEVELOPMENT OF A TRAINING PROGRAM FOR ENHANCING THE USE OF ICT TOOLS IN THE IMPLEMENTATION OF PRECISION AGRICULTURE

Project coordinator

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