Recognition

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Adaptron Inc.

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Recognition is the process of identifying what something is.
In this presentation I explain some fundamental principles for recognizing things based on patterns.

Contents

- Experiences
  - What, where and when
- Patterns – ratios of property values
- Recognition independent of
  - Intensity, position, size, quantity, complexity
- Types of things
- Temporal recognition

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Recognition deals with the what, where and when for recognizing things.

And things are recognized in space and over time. What is recognized are spatial and temporal patterns.

This presentation describes the fundamentals of patterns and how to represent them.

You need to extract the patterns from the readings measured from your senses. These are your experiences.

Everything is relative. A pattern is a relationship.

Patterns are recognized independent of many properties.

Experiences

- Things perceived in particular situations
  - From a combination of senses and sensors
  - The source of measurements for recognition

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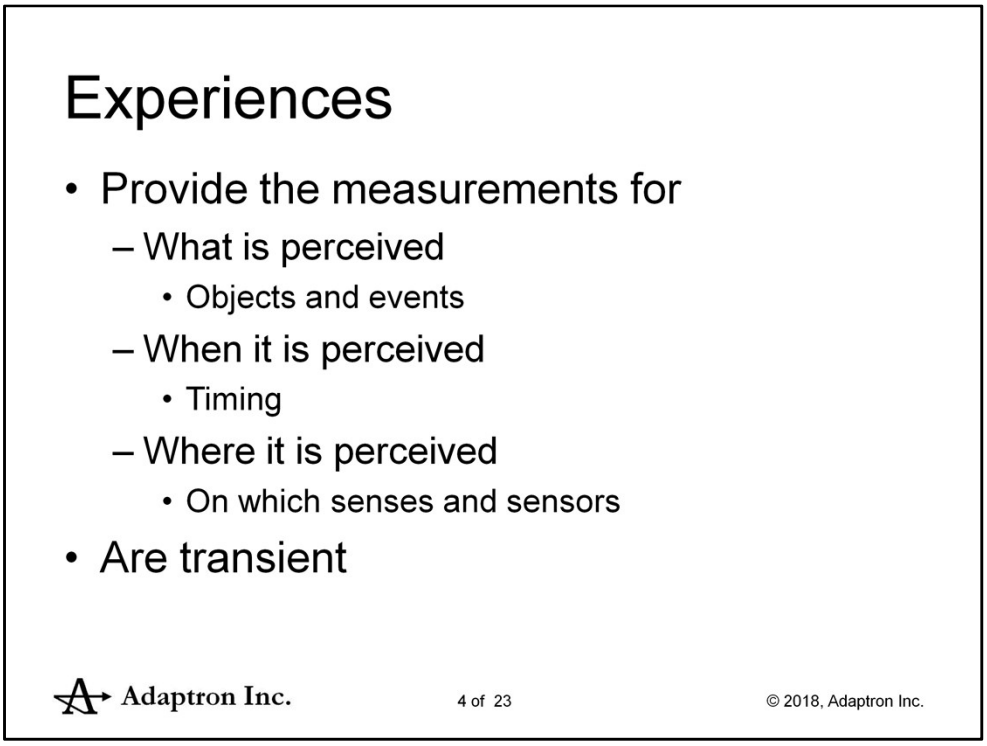
Every time you perceive something you have an experience.

The thing experienced is remembered, not the experience.

The experience is the source of information from which the things are extracted / recognized.

Measurements are the absolute values provided by the sensors to form the experience.



Experiences are a combination of What, When and Where information.

Relative Where information is used in recognition.

Absolute Where information is used in action control and is dealt with in the presentation on Experiences.

Experiences are dynamic. The measurement values are transient.

Things have properties

- Properties are used to recognize things
  - + Intensity
  - + Quantity
  - + Position
  - + Time
  - + Colour

  - + Etc.

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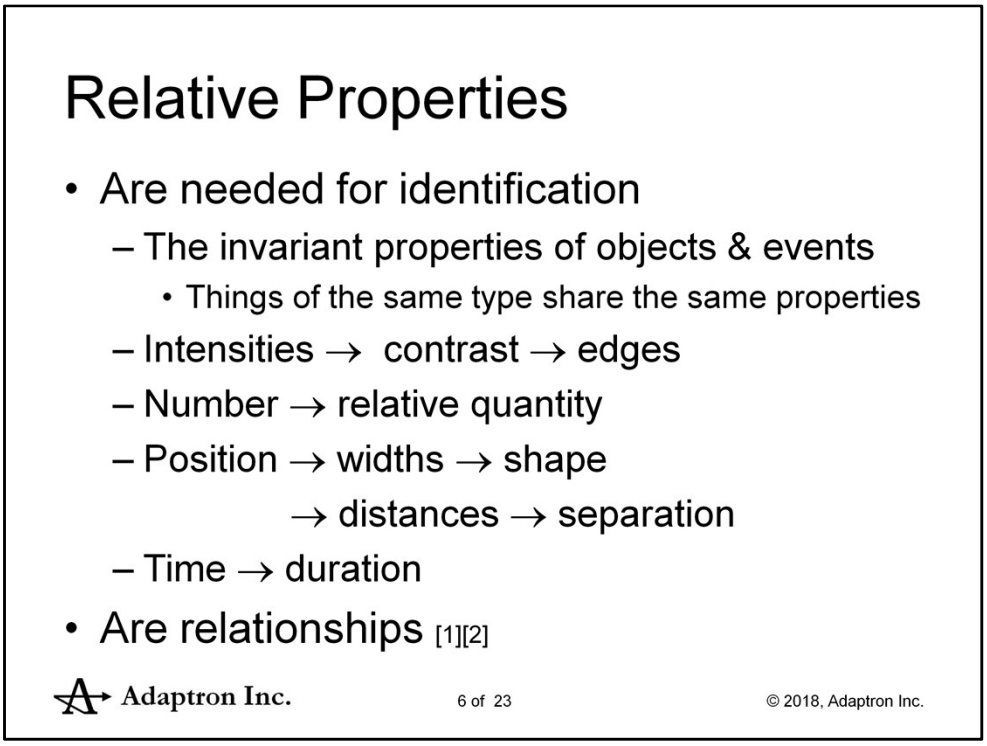
For example, the flags of Bolivia, Sierra Leone, Lithuania, Netherlands, Germany, Yemen are all the same except for their colour property.



Since you have to be able to recognize things in different positions, intensities, sizes, and times, absolute values and not useful.

A single measurement does not tell you **what** has been perceived.

A single pressure measurement at a place on your skin is not enough to tell you what it is. However it does help tell you **where** it is.

A LIDAR reading tells you something is at a distance X and at Y degrees, where it is, but not what it is.

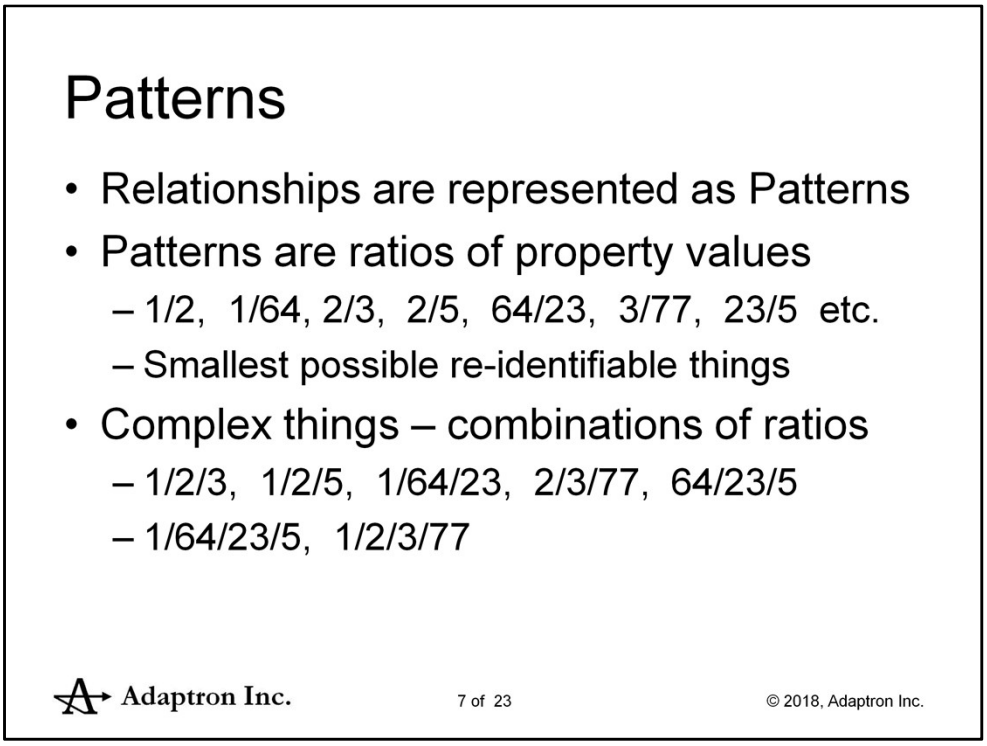
Only the relative values of these properties are useful for identification because for a given thing or type of thing they do not vary.

You recognize things because they have relative properties that allows you to identify them.

With enough properties you may be able to identify the type of thing or if the properties are specific enough you may be able to identify the instance of the thing.

Relative properties are derived from measured properties. For example, relative width gives you shape.

Given a photo of a finger, can you tell whether it is a ring, middle or index finger? You would be guessing. But given a photo of two fingers beside each other, based on relative length, you would be more likely to identify them correctly.



The simplest representation for a relationship / pattern is a ratio. A ratio can be recognized repeatedly. It effectively becomes symbolic.

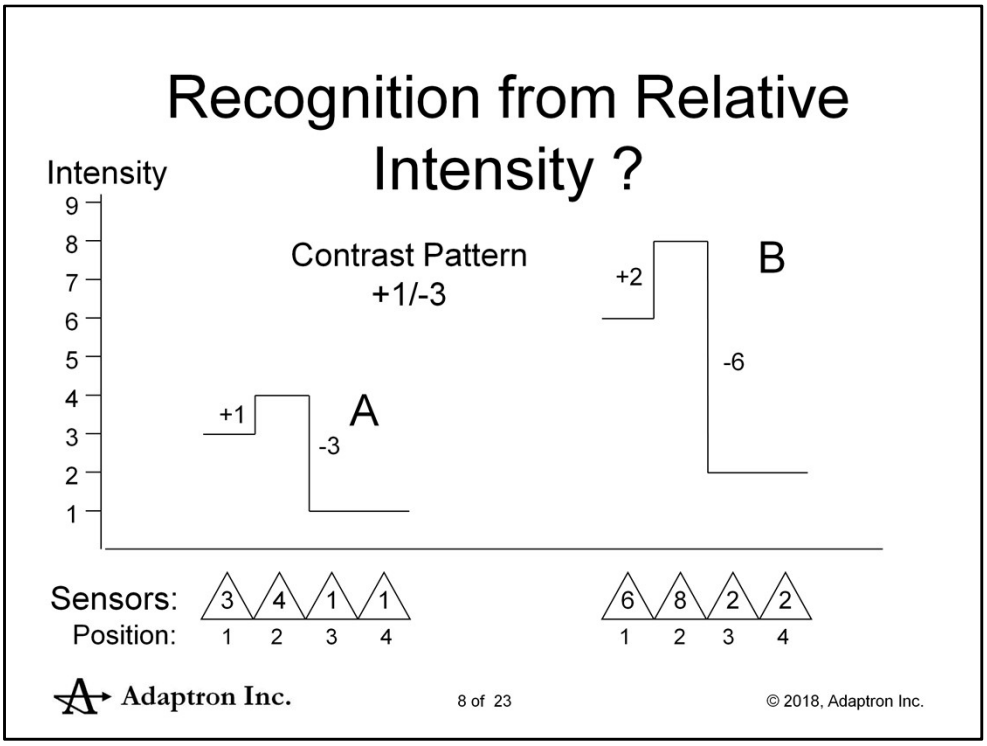
It is a unique identifier for a thing at the simplest possible level.

More complicated things are then combinations of ratios and at each higher level become more specific representations.

Lowest level ratios are reused in these combinations just as some things share common properties.

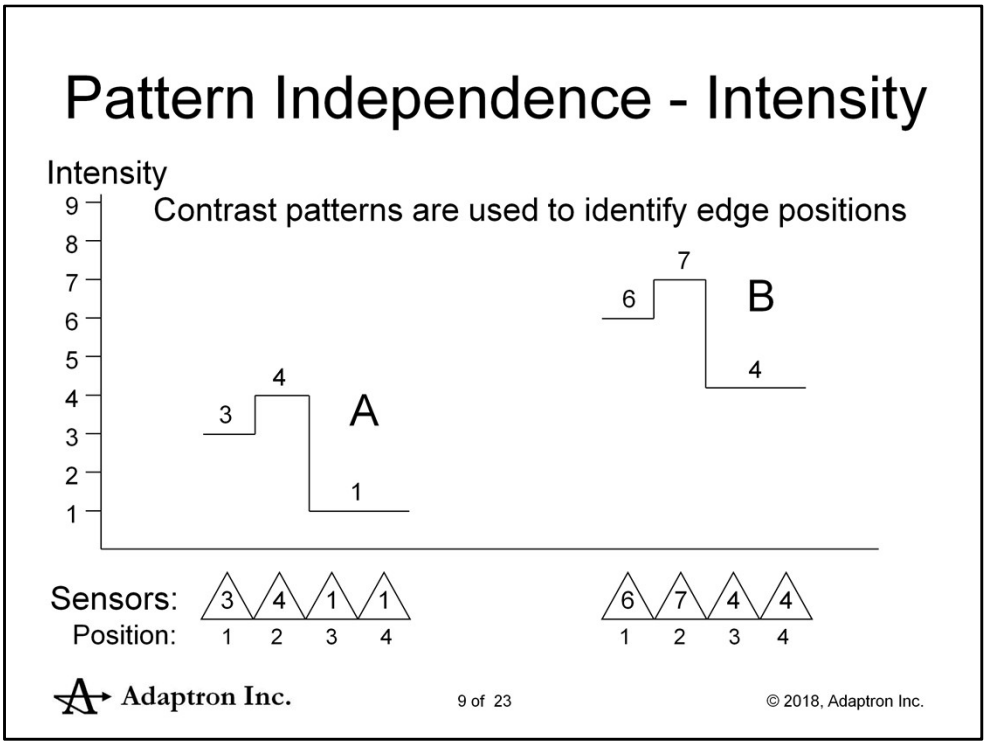
Levels of complexity – measurements are at level 0

Ratios are symbolic and symbolic stimuli are at level 1 – the first level at which things can be recognized.



Is the relative difference in intensity (the contrast pattern) useful to recognize things??

Or is it just useful to find the edges and the edge positions are important for determining shape??

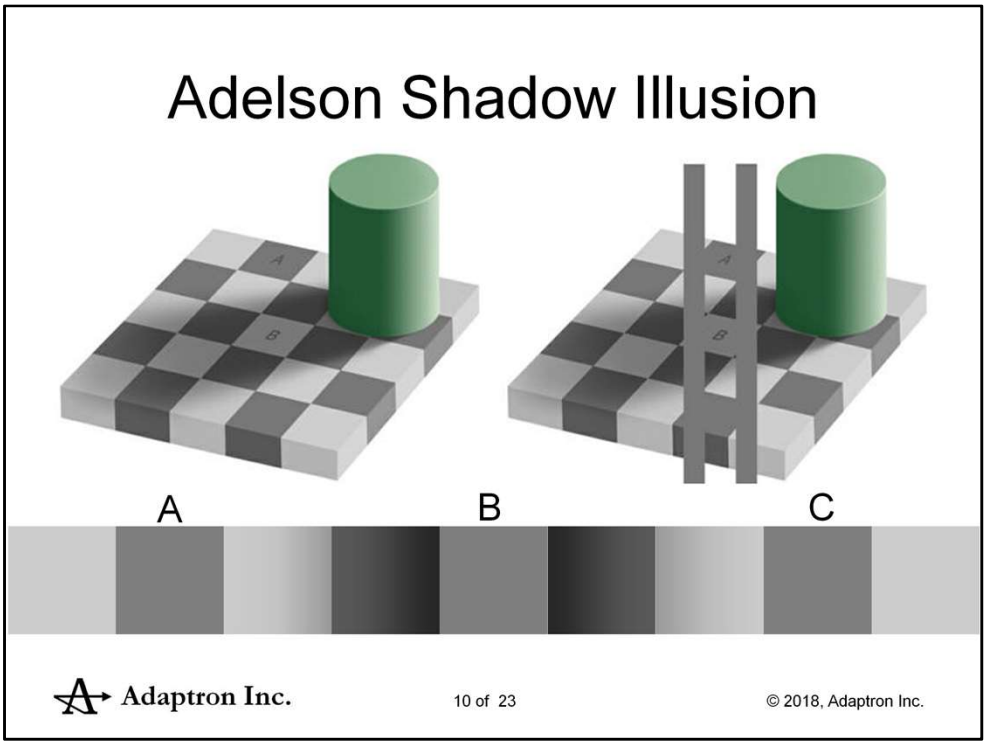


You can recognize a thing in bright light or in the shadows.

A chord can be recognized independently of its volume.

Happy Birthday played softly or loudly is still happy birthday.

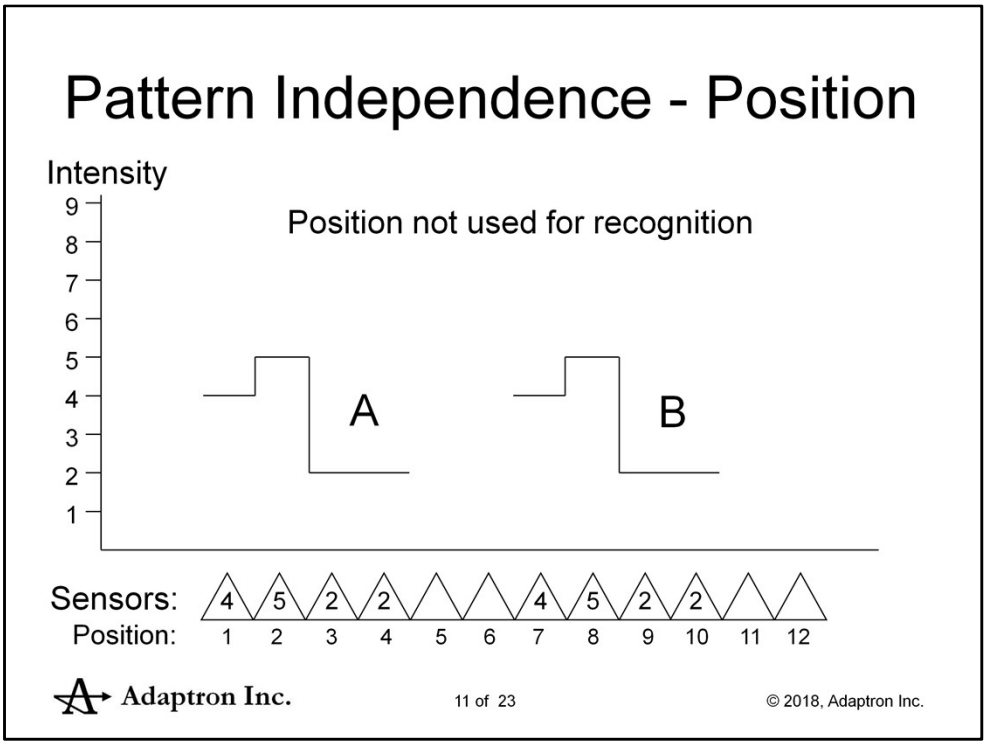
All the examples like this that I provide in these presentations are based on a one dimensional array of sensors.



The checker shadow illusion is an optical illusion published by Edward H. Adelson, Professor of Vision Science at MIT in 1995.

Gradual changes in intensity are less noticeable than sharp changes at edges.

It can be reproduced in one dimension. It works because the intensity in the two intermediate squares gradually changes.

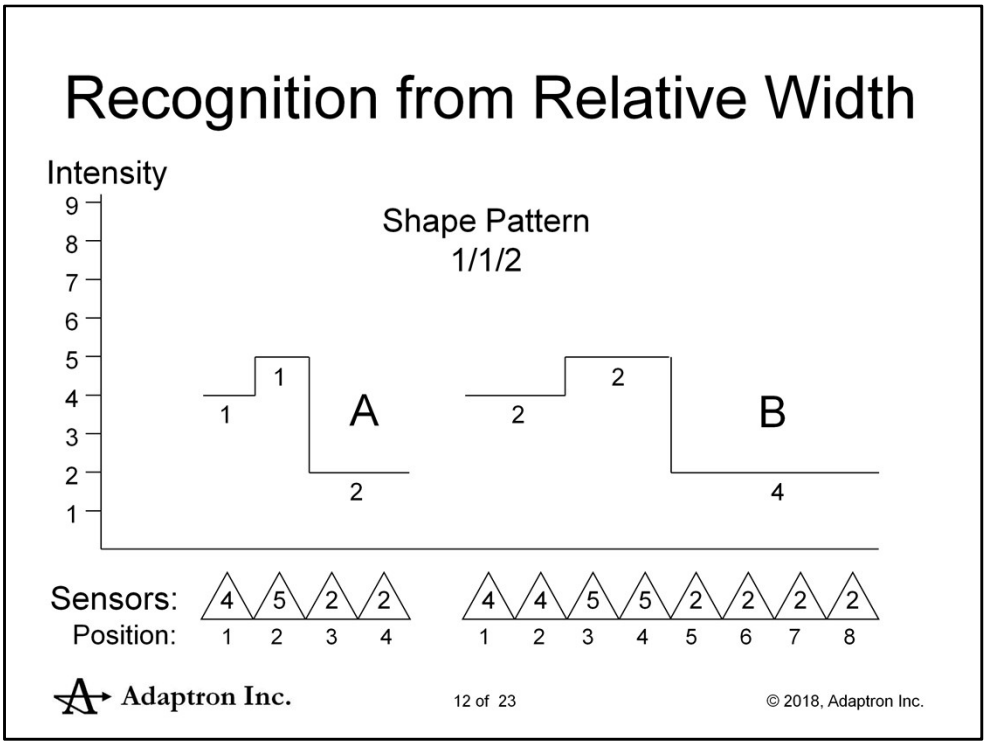


Since things need to be recognized in many situations they need to be identifiable independent of many properties such as position.

A piano as an example – piano keys are equivalent to the sensors and Intensity = volume.

A chord on a piano is recognizable at many different positions on the keyboard.

Happy Birthday played at a different pitch is still Happy Birthday

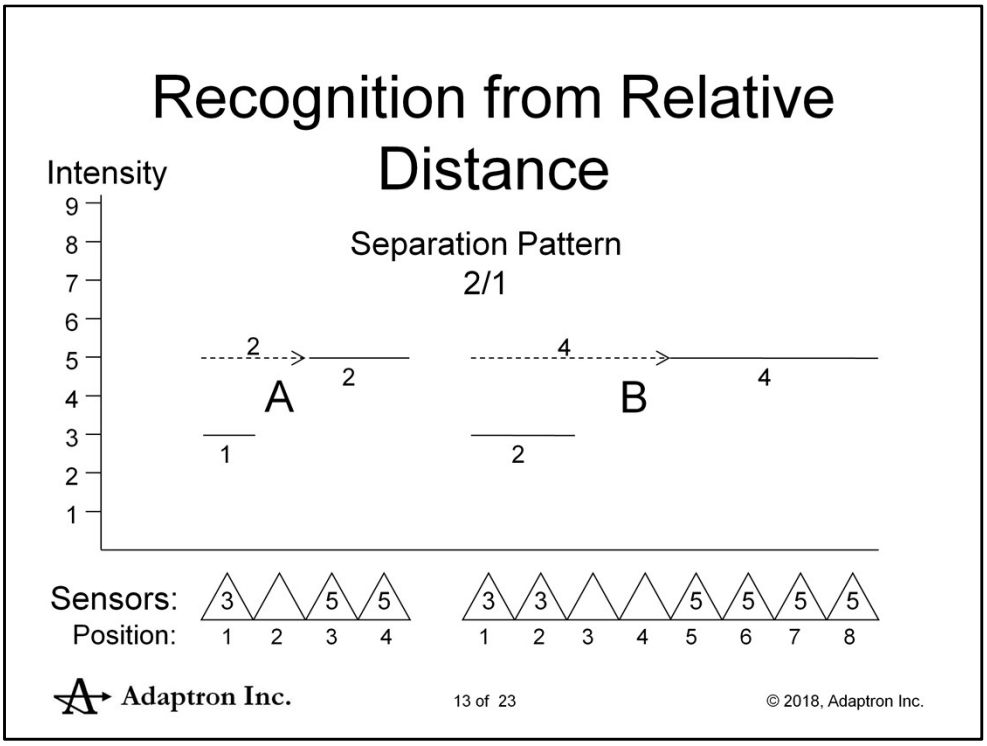


Shape is useful to recognize **What** a something is.

If this was vision you would recognize the second thing as being closer to you because it takes up more of your retina.

In temporal recognition the positions would be equivalent to time.

Happy Birthday is still be Happy Birthday if played slowly or quickly.



Where something is depends on its relative distance from other things.

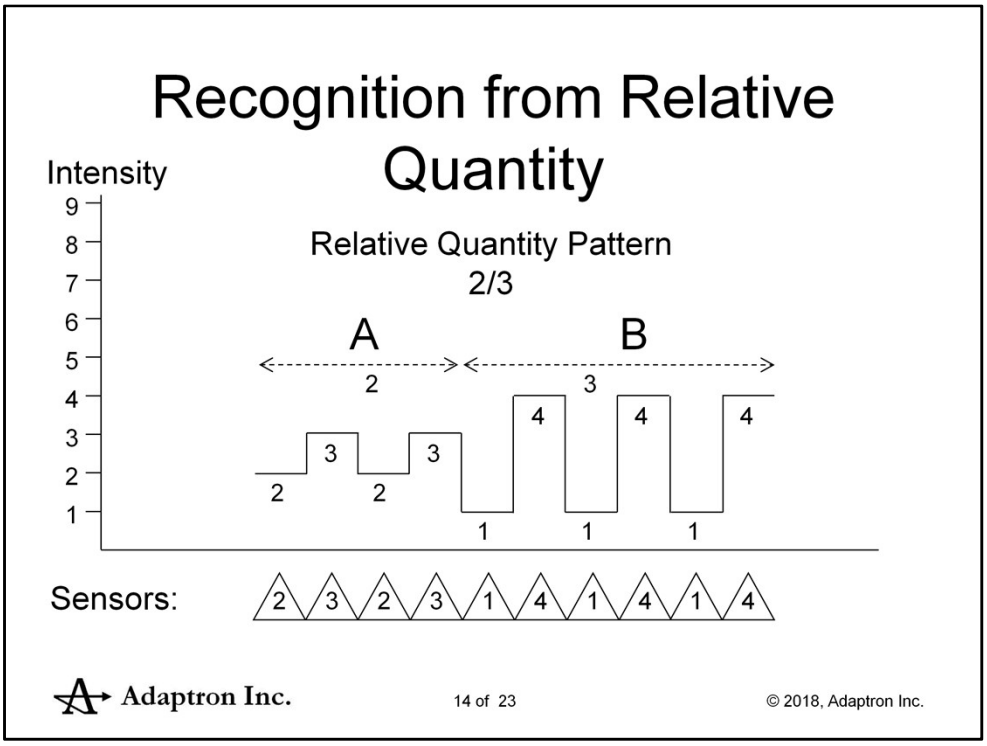
The separation pattern provides the relative distance information for recognition purposes.

It is the ratio of the distance between the two objects to the width of the first object.

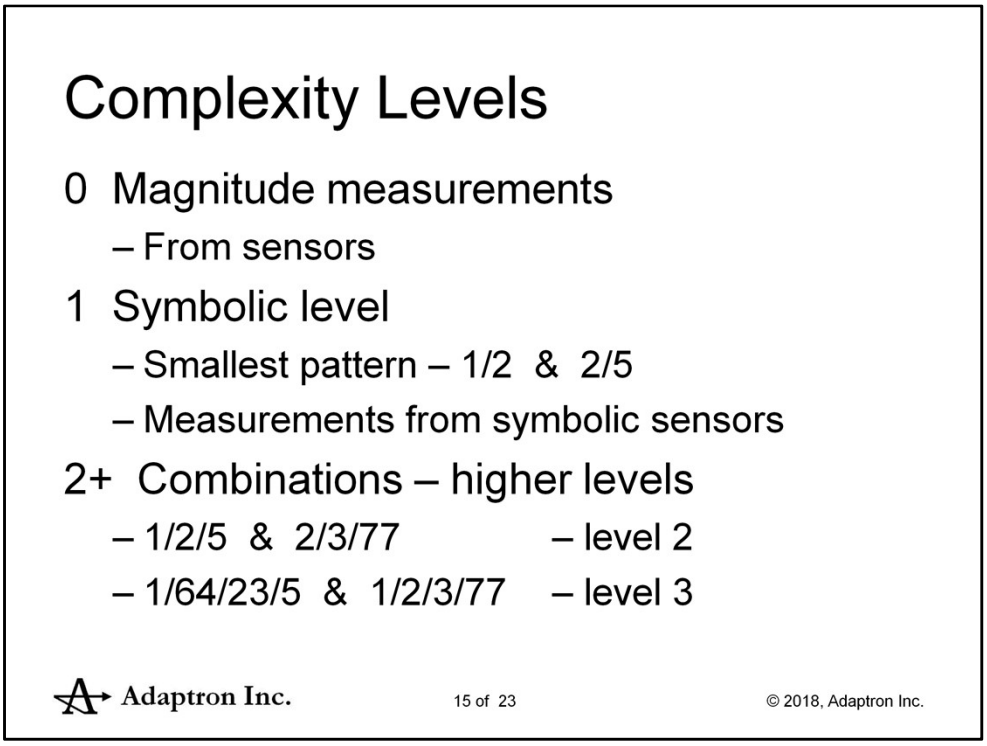
It is 1/1 if the two shapes are adjacent (next to each other).

It is greater than 1 if they are separated by a gap.

It is less than 1 if they overlap.



Quantity is a property that is determined at every level of complexity as a result of identifying repeating patterns.



The level of complexity is based on how many measurements are combined to recognize a thing.

At the sensor level a single magnitude measurement is at level zero complexity and is insufficient to recognize anything.

A symbolic measurement is at level one complexity and is already an identifiable thing.

Symbolic sensors have the ability to provide a symbolic identity for what they perceive.

A symbolic sensor might scan text and provide letters and punctuation symbols.

Complexity Levels

- Complexity level of a thing
  - Corresponds to the experience level
    - If the the parts are at the sensor level
  - The parts of a pattern may be complex
  - Shape, separation and quantity patterns can reoccur at all levels of complexity

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A thing of a given complexity can be perceived at many different levels of experience.

I have seen a portrait of someone famous composed of little pictures of different brightness.

Pattern Independence – Complexity Level Example

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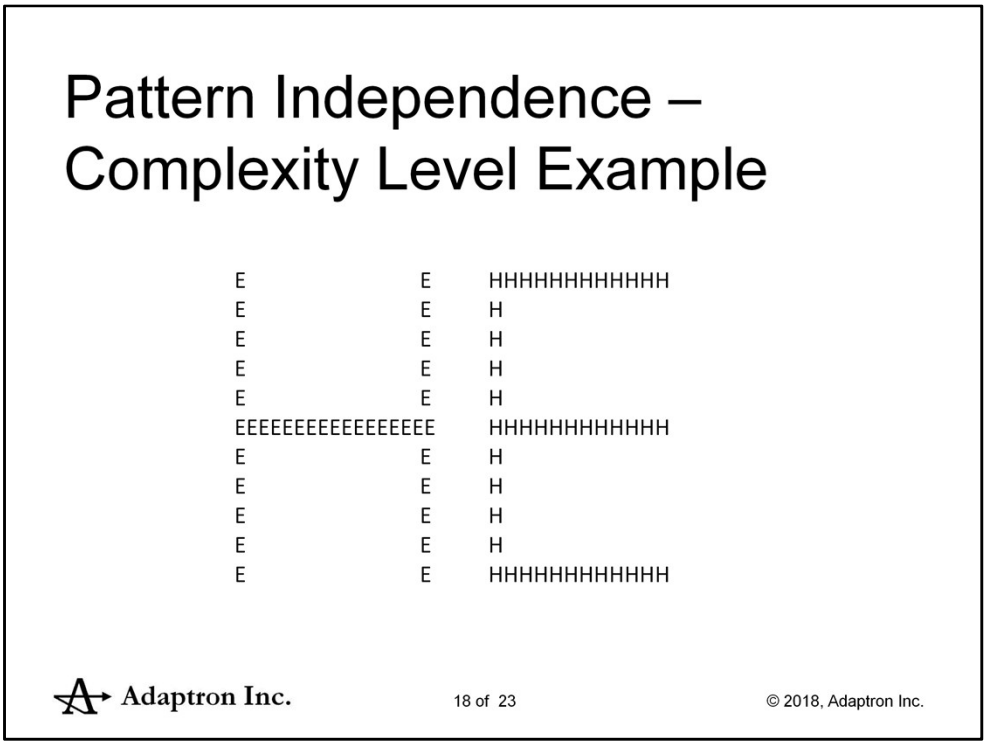
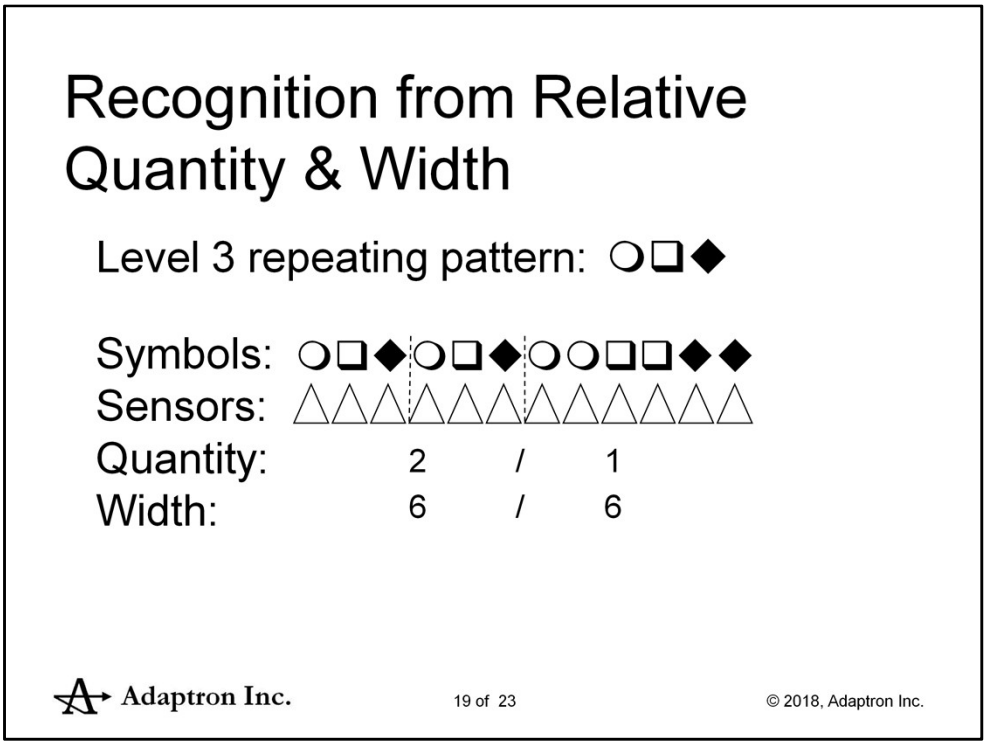
Vincent van Gogh is comprised of many different things which are at a lower level of complexity.



This two-dimensional example is a simple illustration of this principle.

The big H and E are at a higher experience level of complexity compared with the smaller Hs and Es of which they are composed.

However as a thing an H has only one thing level of complexity. Similarly for an E.



[Wingdings = m q u]

These relative quantities are easier to see using symbolic stimuli (level 1 complexity things).

he level 3 thing repeats and as soon as this happens you can determine quantity. Quantity is determined / measured at every level of experience.

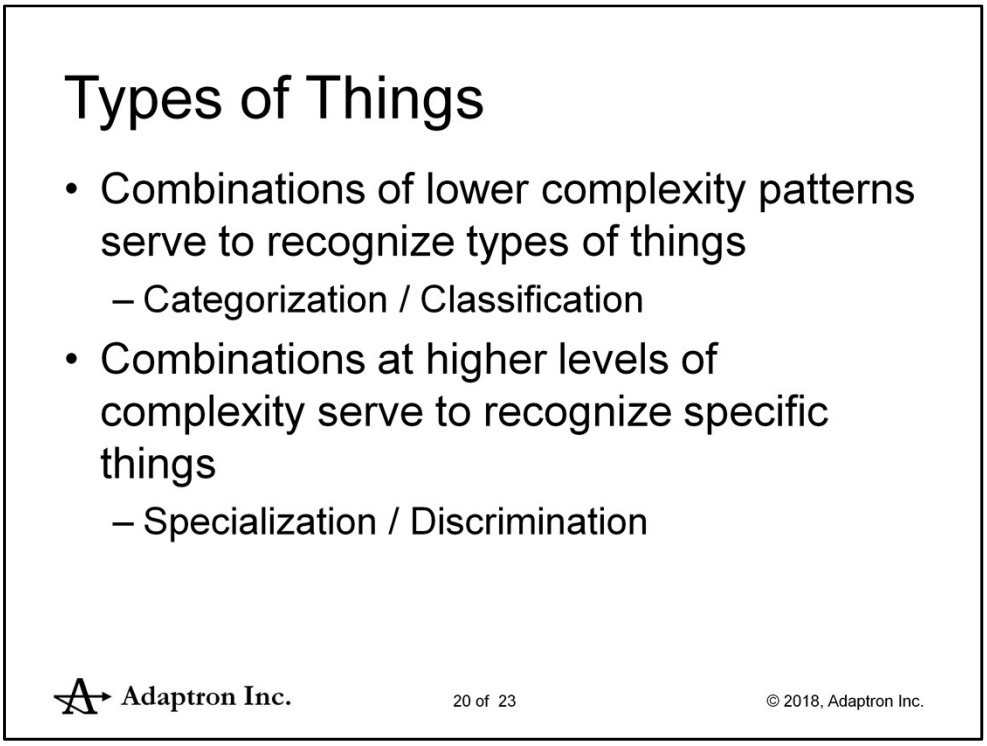
Quantity and width are independent of each other.

At level 0 the size of a sensor is one. The quantity is the number of times adjacent sensors repeat the same intensity which is also the width at level 0.

Quantity is recounted at each level of experience. The shape is determined from the relative widths.

The experience here is two of the patterns at size three resulting in a width of six, on the left and one of the same thing at width six on the right.

In recognition repeating patterns of the same size are always recognized first to determine their quantity.



The colours alone on a flag do not always identify to which country it belongs. Canada and Japan are both red and white.

Add some shape properties such as stripes and a quantity property such as three stripes and you can now discriminate to which country the flag belongs.

Category learning (also called concept learning) is what pattern recognition does when it only recognizes a class / type of thing rather than an instance of that type.

Temporal Experiences

- Intensity changes provide edges in time
  - Instantaneous events
- Temporal pattern
  - Duration pattern – what
  - Separation pattern – relative timing
  - Quantity pattern – repetition

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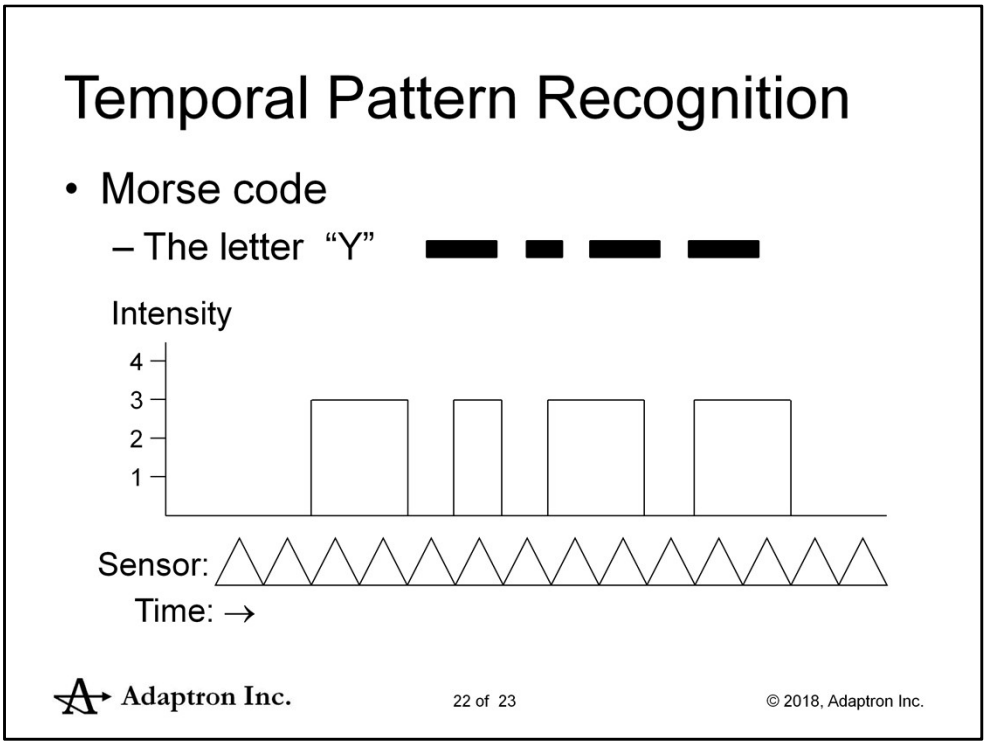
If we now think of the time scale just like the position scale then all the same principles apply.



The time shape of the pattern determines the letter.

The time shape is the relative lengths of the dashes and the dots to each other, and the order in which they occur.

This also includes the relative length of time between letters to distinguish one letter from the next.

The duration of a dash or a dot does not identify it.

It is the relative duration of a dash to the gap and the relative duration of the gap to the dot that are important.

This allows for the Morse code speed to change but still be recognizable.

References

[1] Halford, G. S., Wilson, W. H., & Phillips, S. (2010). Relational knowledge: The foundation of higher cognition. *Trends in Cognitive Sciences*, 14(11), 497–505. doi:10.1016/j.tics.2010.08.005

[2] Mathis Richter, Jonas Lins, Gregor Schöner (2018). A Neural Dynamic Model Generates Descriptions of Object-Oriented Actions. Topics in Cognitive Science 9 (2018) 35–47

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