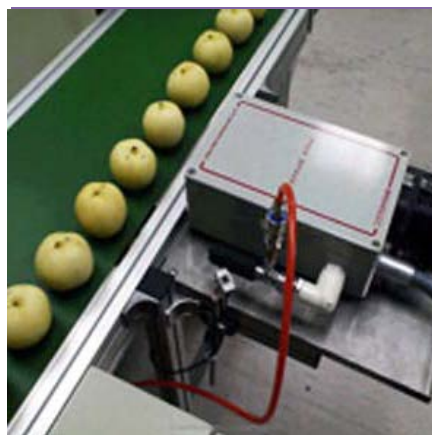




# Sort it Out!

The engineering behind  
industrial sorting processes





# Objectives



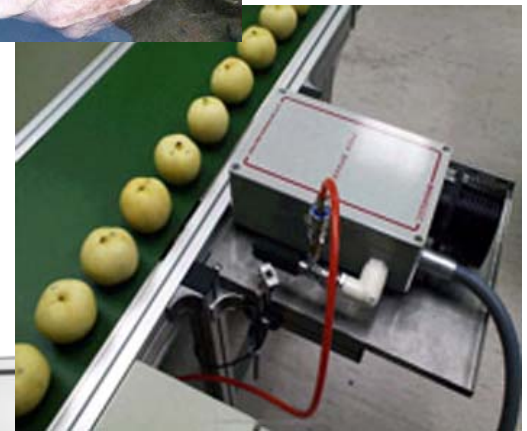
- Learn about engineering of systems and about measurements
- Learn about sorting mechanisms
- Get an introduction to Performance Indices and measures of errors
- Learn about teamwork and cooperation



# Sorting through History



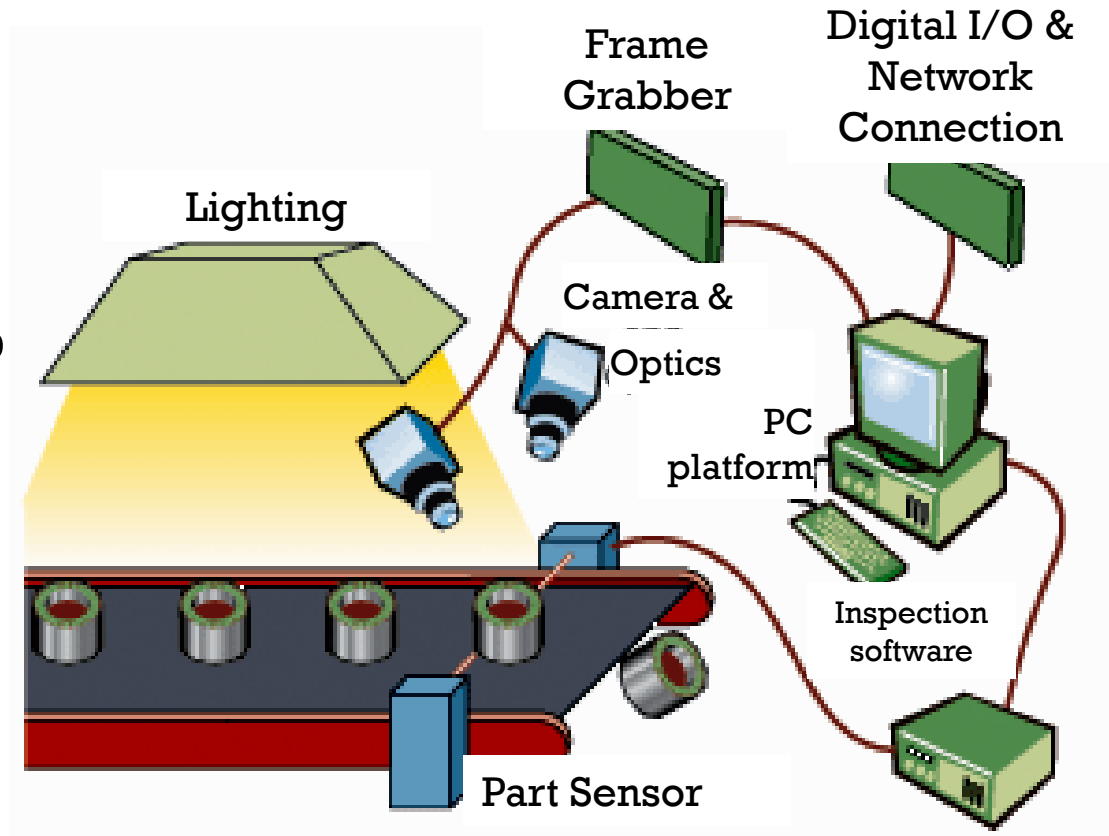
- Miners panning for gold
- Quality control in food and other industries
- Bottle sorting for recycling





# Different Types of Sorting

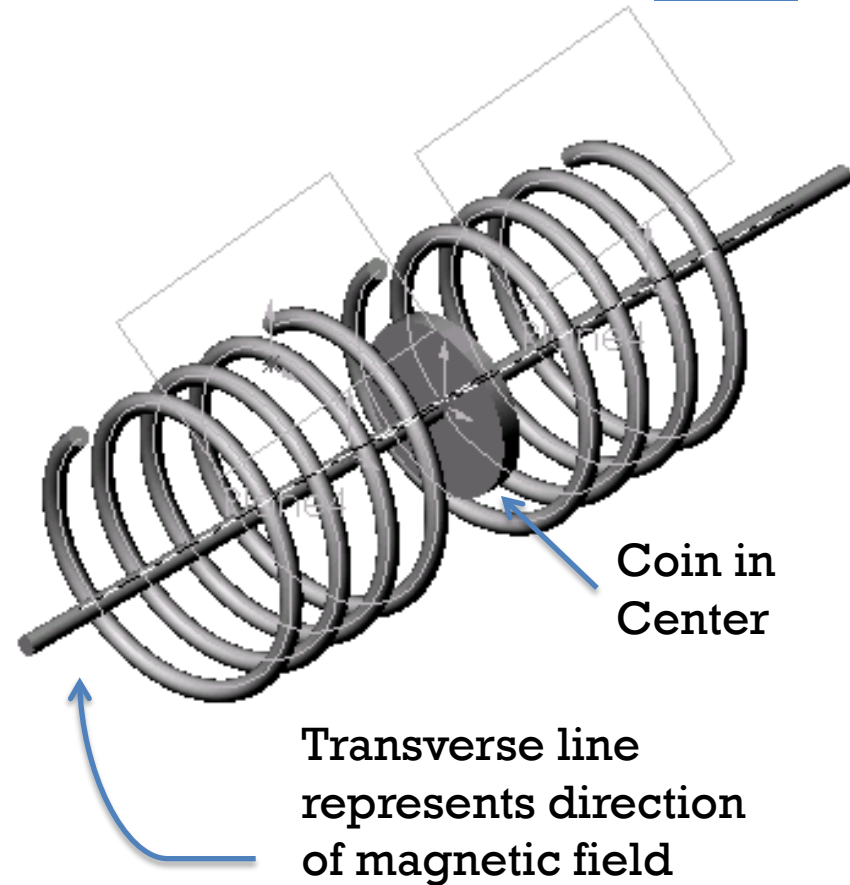
- Image Processing for the operation of Casinos:
- Off-the-shelf cameras, frame grabbers, and image-processing software used to develop a casino-coin sorting system





# Different Types of Sorting

- Material Properties of Coin:
  - Current run through left coil, creates magnetic field
  - Magnetic field passes through and is attenuated by coin
  - Right coil receives magnetic field, creates measurable current with different value depending on the coin





# Why Coin Sorting is Needed

- Mixed coins come from a variety of sources and must be sorted out before they can be redistributed
  - Coins from vending machines
  - Coins from parking meters
- Also helpful to identify fake or foreign coins





# Why Coin Sorting is Needed

- Mixed coins are
  - Sorted
  - Rolled
  - Re-circulated through banks and businesses





# Your Turn

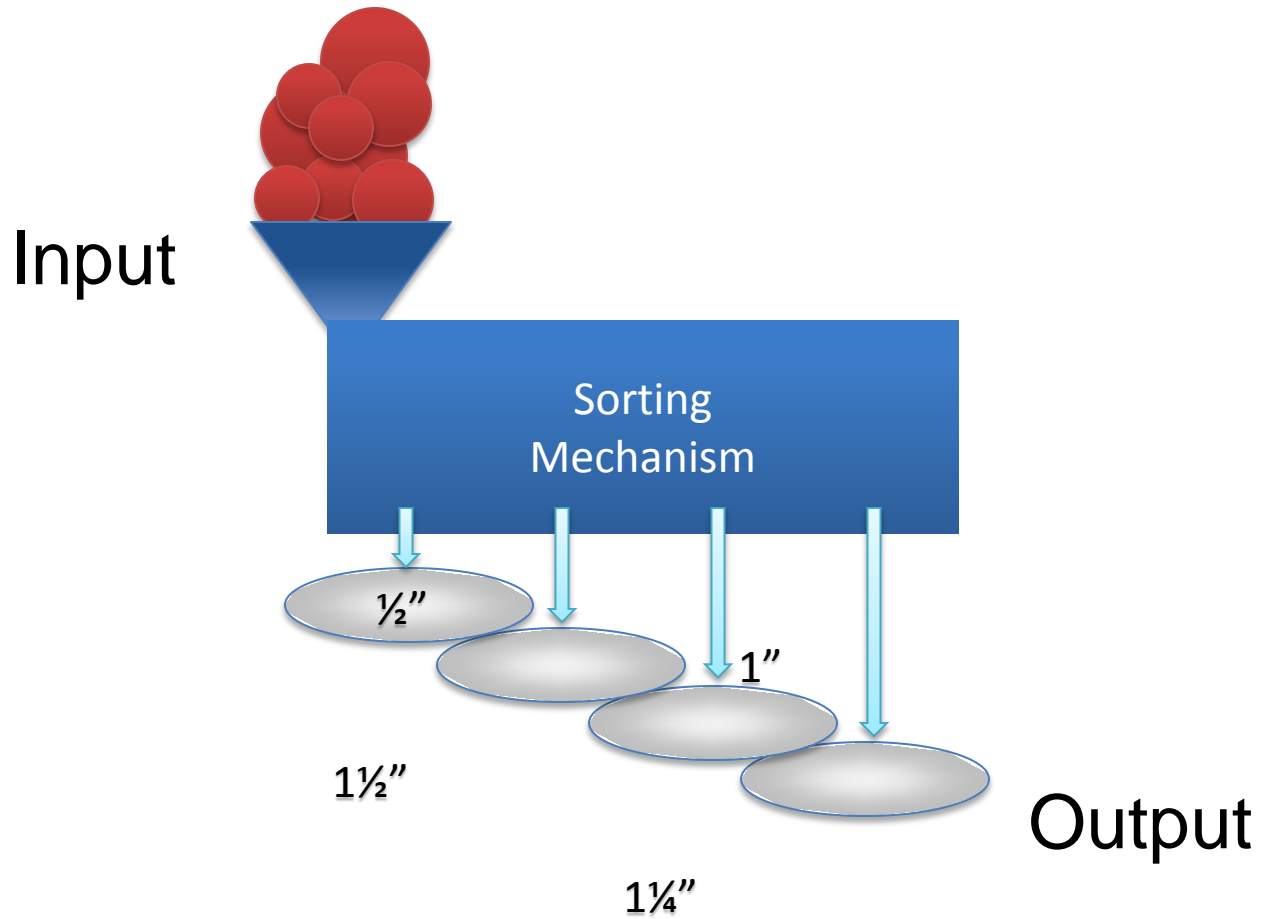
- Groups of 2
- You are a team of engineers hired by a bank to develop a machine to sort coins that are brought in by customers.
- Must mechanically sort mixed coins into separate containers.
- In our experiment we use washers:
  - $\frac{1}{2}$  Inch
  - 1 Inch
  - $1\frac{1}{4}$  Inch
  - $1\frac{1}{2}$  Inch





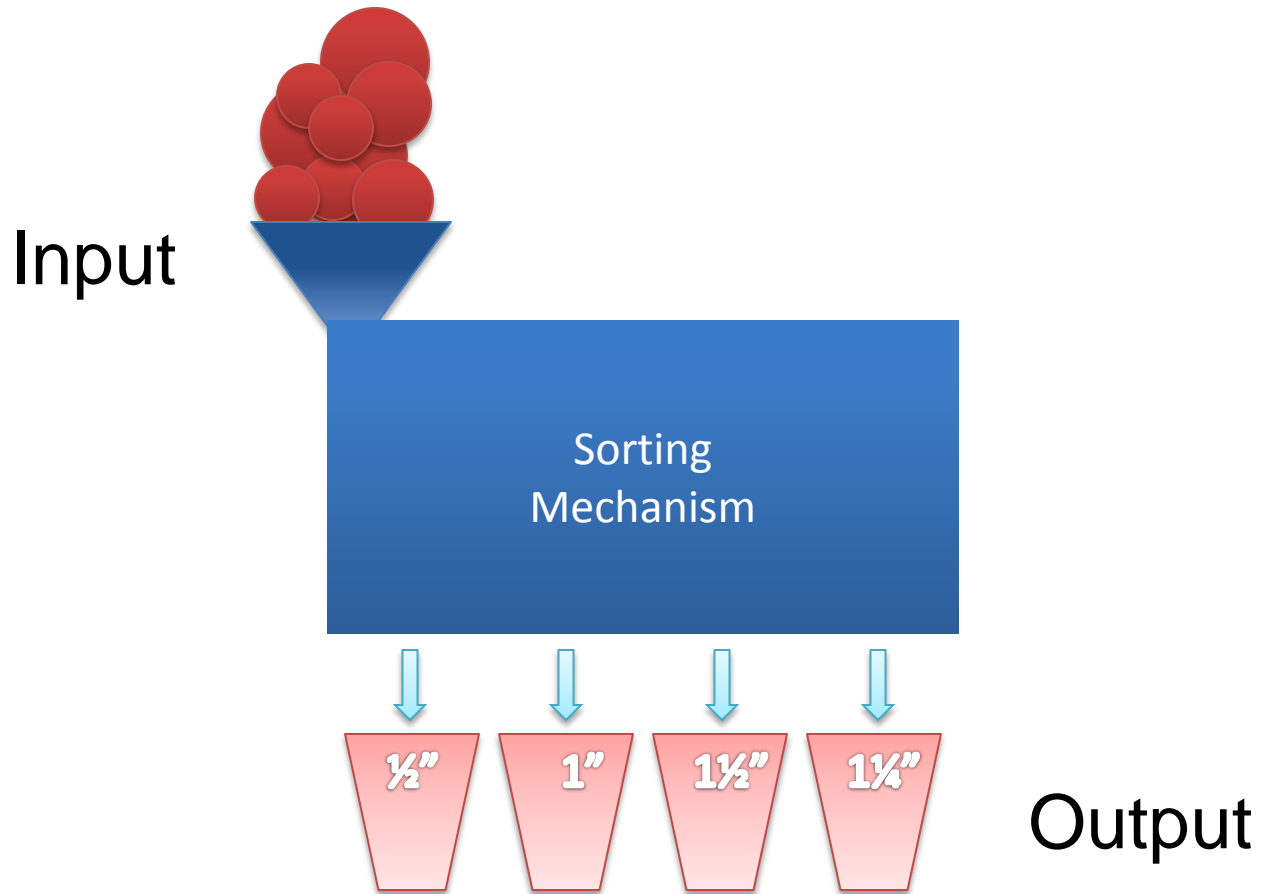


# Parallel Sorter





# Parallel Sorter

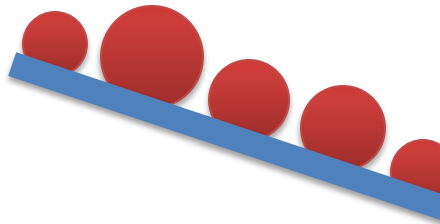




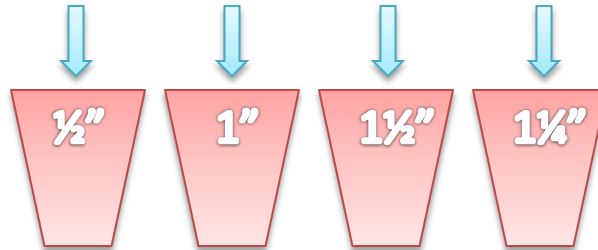
# Serial Sorter



Input



Sorting  
Mechanism



Output

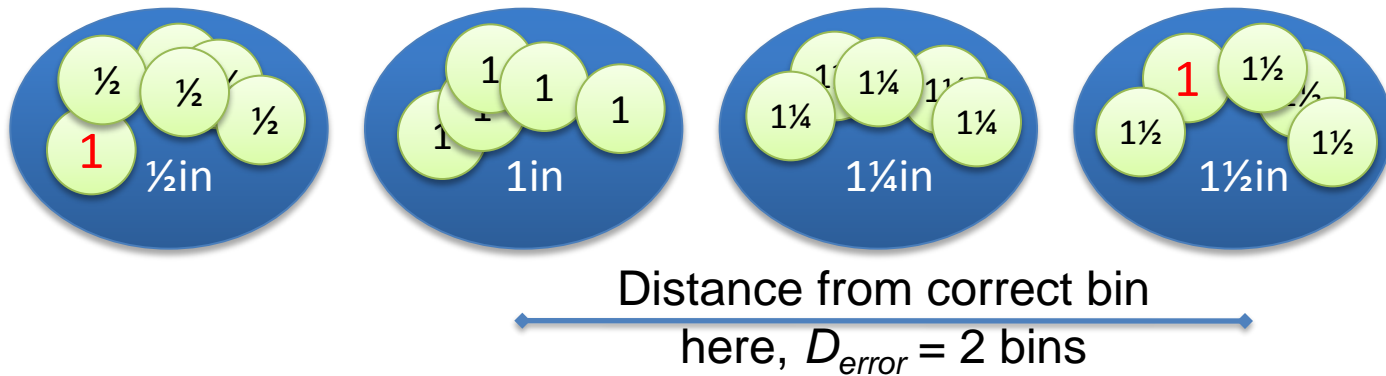


# Performance Index 1: “Distance Index”



How good is it?

- 1: “Distance” performance index:



$$Index = \sqrt{\sum_i D_{error,i}^2} = \sqrt{4 + 1} \approx 2.24$$

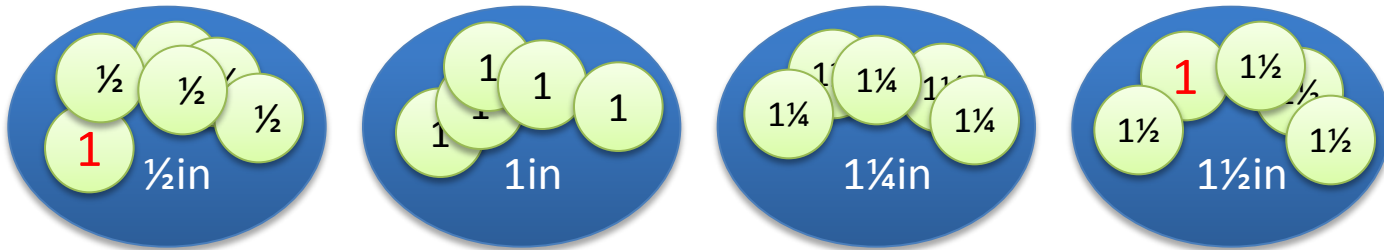
- A washer that does not get sorted has maximum  $D_{error} = 3$

# + Performance Index 2: “Percentage Index”



How good is it?

- 2: “Percentage” performance index:



$$Index = \frac{\text{\# of washers incorrectly identified}}{\text{Total \# of washers to sort}} \times 100 = \frac{2}{40} \times 100 = 5\%$$

# Sort It Out!

Table Number:				Type of Sorter	Serial	
Team Name:				Parallel		
# of this type in each container	Container for this size washer:				Total washers sorted:	16
	<u>1/2"</u>	<u>1"</u>	<u>1 1/4"</u>	<u>1 1/2"</u>		
	1/2":				Number left unsorted:	
	1":				Distance Index:	
	1 1/4":					
1 1/2":				Percentage Index:		

# Sort It Out!

Table Number: <b>16</b>		Type of Sorter <b>Serial</b>		
Team Name: <i>The Perfect Group</i>		Parallel		
# of this type in each container	Container for this size washer:			Total washers sorted: <b>16</b>
	<u>1/2"</u>	<u>1"</u>	<u>1 1/4"</u>	<u>1 1/2"</u>
	<b>4</b>			
	<b>1/2":</b>			Number left unsorted: <b>0</b>
	<b>1":</b>	<b>4</b>		
<b>1 1/4":</b>		<b>4</b>		Distance Index: <b>0</b>
<b>1 1/2":</b>			<b>4</b>	Percentage Index: <b>0%</b>

# Sort It Out!

- Distance Performance Index
  - $\text{sqrt}(0 \times 1^2 + 0 \times 2^2 + 0 \times 3^2) = 0$
  - A Perfect Score!
    - Remember: Lower is better
- Percentage Performance Index
  - $(0 / 16) \times 100 = 0\%$
  - Another Perfect Score!



# Sort It Out!

Table Number: <b>16</b>		Type of Sorter <b>Serial</b>			
Team Name: <i>Not That Perfect</i>		Parallel			
# of this type in each container	Container for this size washer:			Total washers sorted: <b>16</b>	
	<u>1/2"</u>	<u>1"</u>	<u>1 1/4"</u>	<u>1 1/2"</u>	
<b>1/2":</b>	<b>4</b>				Number left unsorted: <b>0</b>
<b>1":</b>		<b>4</b>			Distance Index: <b>1</b>
<b>1 1/4":</b>			<b>4</b>		
<b>1 1/2":</b>			<b>1</b>	<b>3</b>	Percentage Index: <b>6.25%</b>

# Sort It Out!

- Distance Performance Index
  - $\text{sqrt}(1 \times 1^2 + 0 \times 2^2 + 0 \times 3^2) = 1$
  - A Less Than Perfect Score!
    - Remember: Lower is better
- Percentage Performance Index
  - $(1 / 16) \times 100 = 6.25\%$
  - A Less Than Perfect Score!

# Sort It Out!

Table Number: <b>16</b>		Type of Sorter <b>Serial</b>			
Team Name: <i>The Truly Miserable</i>		Parallel			
# of this type in each container	Container for this size washer:				Total washers sorted: <b>16</b>
	<u>1/2"</u>	<u>1"</u>	<u>1 1/4"</u>	<u>1 1/2"</u>	
<b>1/2":</b>	<b>1</b>	<b>1</b>	<b>1</b>	<b>1</b>	Number left unsorted: <b>2</b>
<b>1":</b>		<b>4</b>			Distance Index: <b>6.16</b>
<b>1 1/4":</b>	<b>4</b>				
<b>1 1/2":</b>				<b>2</b>	Percentage Index: <b>56%</b>

# Sort It Out!

1/2":	1	1	1	1	Number left unsorted: 2	
1":		4			Distance Index:	6.16
1 1/4":	4					
1 1/2":				2	Percentage Index:	56%

- Distance Performance Index
  - $\sqrt{1 \times 1^2 + 1 \times 2^2 + 4 \times 2^2 + 1 \times 3^2 + 2 \times 3^2} = 6.16$
  - Much higher score, much lower performance
    - Remember: Lower is better
- Percentage Performance Index
  - $(9 / 16) \times 100 = 56.25\%$
  - Again, much lower performance



# Sort It Out



## Your Turn

**Mechanical “shaking” of your device is allowed as part of its operation**

- Design (draw) a mechanical sorter that can separate the ½in, 1in, 1¼in, 1½in washers
- Input: either
  - Parallel – all 16 washers are inserted at start of your sorter together; or
  - Serial – 16 washers are inserted at start of your sorter one at a time
- Output: Each size of washer in its own physical container or surface
- Materials:
  - glue, tape, paper or plastic plates, cardboard, scissors or hole punch, foil, paper, cardboard tubes
  - washers





# Your Turn



- You will have 45 seconds to allow your sorter to operate
- Predict the value of the two performance indices for your design
- Construct your sorting mechanism
- Test it!
- Can you do better?

**Mechanical “shaking” of your device is allowed as part of its operation**



# Conclusion



- Did your sorting mechanism work? If not, why did it fail?
- What were your performance index values?
- What levels of error would be acceptable in:
  - Medical Equipment manufacturing?
  - Nail manufacturing?
- What redesigns were necessary when you went to construct your design? Why?