The Rocky Road from URS to FAT.

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AVI Vision Component / Software Algorithm selection & System Testing

- What are the critical items in a URS for a AVI system.
  (AVI Automatic visual Inspection)
  (URS User Requirement Specification)

- Critical Design improvements in our AVI systems by specifying Hardware components.

- Critical Design improvements in our AVI systems by specifying Software Algorithms.

- How do we test our systems after these improvements. Gap in AVI implementation by just relying on MVI-based Knapp studies.

- The Future of AVI
Approx. time from ordering a AVI system to FAT.

10 months to 18 months

Requirements can change and specifications can change in this period.

Design where possible for this.
What do you think of when you think of a Vision system to inspect your containers.
This is how you should see a vision system when you are considering a URS.

- Sensing and Digitizing image Data
- Image Processing and Analysis
- Applications

- Source code / Vision Algorithms
- Display
- Interface
- Robot Controller
- HMI or operator input
- Tasks: Reject Accept Eject
- Dedicated Vision Processor / Industrial PC
- Frame Grabber
- Lens/filters
- Cameras
- Spin/inversion
- Illumination/filters

Tasks:
- Reject
- Accept
- Eject
What is in the URS?
User Requirement Specification

Or maybe a better question

What is in the not in the URS?

<table>
<thead>
<tr>
<th>Critical Design Item</th>
<th>Why Important</th>
<th>Out of 100 pages URS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Illumination</td>
<td>Most critical item in any vision system.</td>
<td>0</td>
</tr>
<tr>
<td>Cameras</td>
<td>No camera no image.</td>
<td>2 times mentioned</td>
</tr>
<tr>
<td>Filters</td>
<td>Critical to finding fibres</td>
<td>0</td>
</tr>
<tr>
<td>Frame Grabbing boards</td>
<td>More frames more defects detected</td>
<td>0</td>
</tr>
<tr>
<td>Software / Algorithms</td>
<td>Without this we have a very expensive material handling device from A to B</td>
<td>0</td>
</tr>
</tbody>
</table>

The above table shows in a typical URS how many times the most important items are referenced.
QUESTION 1

How many people involved in any way in the specification of a AVI system?

How long should a design review take?

What Level of technical interaction is needed?

How many People have specified a Frame Grabber or camera interface?
### Frame Grabber and camera Interface

<table>
<thead>
<tr>
<th></th>
<th>Camera Link</th>
<th>GigE Vision</th>
<th>IEEE-1394B</th>
<th>USB 3.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Speed (bandwidth)</td>
<td>6.1gb/s</td>
<td>1Gb/s</td>
<td>768mb/s</td>
<td>5gb/s</td>
</tr>
<tr>
<td>Cabling</td>
<td>multicore</td>
<td>Cat-6</td>
<td>Complex</td>
<td>Complex</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Mass produced</td>
<td>Mass produced</td>
</tr>
<tr>
<td>Cable Length</td>
<td>10m</td>
<td>100m</td>
<td>4.5m</td>
<td>3 m</td>
</tr>
<tr>
<td>Real Time Trigger</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Power over cable</td>
<td>PoCL 4W</td>
<td>PoE13w</td>
<td>Yes</td>
<td>4.5w</td>
</tr>
</tbody>
</table>

Some camera interfaces are easier to use but don’t necessarily give you the best quality.

Example: Higher bandwidth means you can take more images in one sec.

So you don’t have to talk technical.

Ask the question: How many images per second will the system give me per sec per station.
Frame grabber and image digital interface
impact defect detection

It’s the part of the design that determines how many frames per sec you get from the container inspection. The cracks are the red lines shown below.

Clearly in this example the bad crack can be seen using multiple images.
QUESTION 2

How many People have specified the camera used in their system?

Any machine vendors here
VENDOR DESIGN INERTIA (VDI)

Cameras: A brilliant little camera The Sony HR-50. Used it 20 years ago. All the top AVI vendors use it or similar !!!!!!! This camera is outdated.

Need to stress again because so many people say. “But we are not interested at seeing down to the 20um level”. This is not about sub visible particles as will be shown later.

We have Proven VDI in the pharma business not only with cameras but in most of the core Vision technologies used.

A cool ANALOG camera for its day. A great car for its day.
What does 100µm particle look like with a 640 x480 resolution camera
What does 100µm particle look like with a 1200 x 926 resolution camera
Camera Resolution Factor x 4

100µm Particle

640 x 480 pixels

1200 x 926 pixels
So Standard Camera Resolution Available

Vendor Inertia has keep us down here
QUESTION 3

How many People have outlined some of the key algorithms or where the algorithms should be used.

An algorithm is just a set of steps to solve a problem or in machine vision it can be a set of actions on an image to allow you to make a judgment easier. Example see a particle in a liquid. The algorithm might be enhance the image then following any objects that move in a certain direction.

You can learn how to make algorithms using pseudo-code or real code, that's where you would need programming knowledge. If you want to optimize your algorithms then math comes around the corner. And you have to have basic knowledge about that. It's a combination. But learning about algorithms can be as simple as you want it to be.

So you don’t have to talk technical. Ask the question Does the system have an Algorithm to find particles around the vortex.
Have you asked enough questions about the particle detection algorithms.

Have you an algorithm to catch particles here around the Vortex
Have you asked enough questions about the particle detection algorithms.

Have you an algorithm to catch particles in the Vortex
Have you asked enough questions about the particle detection algorithms.

Have you an algorithm to catch particles stuck on the dome?
Have you asked enough questions about the particle detection algorithms.

Have you an algorithm to handle bubbles on the dome

*Side note:* important to know when to use Nist standards beads Vs irregular shaped defects
Have you asked enough questions about the particle detection algorithms.

Have you an algorithm to discriminate a particle from a bubble
Have you asked enough questions about the particle detection algorithms.

Have you an algorithm to catch particles at the far side of the container.
Have you asked enough questions about the Fibre particle detection algorithms.
QUESTION 4

Grade these industries in highest level of machine vision to the lowest..

[1] Automotive industry. 1
[2] Chicken / Food Sorting Industry. 3
[3] Car plate traffic Industry. 4
[4] Wii Person tracking software. 2
[5] Particle tracking in Syringes 5
Software processing Power (The Brain)

To demonstrate this VDI lets reference Moore’s law: over the history of computing hardware, the number of transistors in a dense integrated circuit has doubled approximately every two years. (Indication on the power of the computer)

We are here today

From Pacman to Lara Croft face changes has taken advantage of Moore’s Law.

Last 2 years in Particle vision:

100um particle 2013 Pharma Industry

Big Void, we are not even using standard 3D technology yet

These innovations reduce false fails and can soon indicate what is a protein or a foreign particle. Roadmap is there

Dream World for AVI

We have made huge advancements in the last two years with particle tracking and morphology etc.
AVI Vision Component / Software Algorithm selection & System Testing

Section 1

• What are the critical items in a URS for a AVI system.
  (AVI  Automatic visual Inspection)
  (URS  User Requirement Specification)

• Critical Design improvements in our AVI systems by specifying Hardware components.

• Critical Design improvements in our AVI systems by specifying Software Algorithms.

Section 2

• How do we test our systems after these improvements.
  Gap in AVI implementation by just relying on MVI-based Knapp studies.
SOLUTION: URS MUST SPECIFY THE COMPONENTS THAT GIVE THE SYSTEM THE CAPABILITY TO FIND WHAT WE WANT.

- Mechanical motions
- Illumination
- Filters
- Lenses
- Cameras
- Image interfaces
- Processing power
- Software/Algorithms Modules

Section 1 of this presentation states when you are specifying a Vision system specify the Vision Components you need.
QUESTION 5

How many People have heard of Julius Knapp?
Is the Knapp study comparing a Manual process and automatic process sufficient to confirm actual capability of an AVI system?
Section 2 addresses gaps in the Knapp study.

How do we test our systems after these improvements

We need to consider these factors when considering AVI final testing:

- Particle Size, shape
- Particle Surface determines interaction with light
- Particle Colour
- Particle Density
- Particle Quantities across size ranges
- Container Diameter
- Container Spin /inversion rate possible
- Container hidden zones
- Container liquid viscosity and surface tension
- Container Fill volume

Side Note:
How many stations will be needed on the system. In this case different particles may require different stations.
DENSITY Of the Particle

Key Points.

[1] Density is key \(1000\text{kg/m}^3 = 1\text{g/cm}^3\)

- Formulation \(~1.02\ \text{g/cm}^3\)
- Polystyrene \(1.05\ \text{g/cm}^3\)
- Glass \(2.4-2.5\ \text{g/cm}^3\)
- Cellulose \(1.5\ \text{g/cm}^3\)
- Metal> \(3.00\ \text{g/cm}^3\)
- Protein aggregate \(~1.02\ \text{g/cc}\)

Vial range: Using the spin technique this range of density's is possible.

Syringe range: Using the spin technique this range of density's is possible.

*X axis is the focus, Y axis is not key to this discussion*
All present day Machine Vision Inspection Vendors have particle detection limitations

• Why do these limitations exist in AVIs we are using to inspect Amgen's product and container range?

The core reason we have detection problems is the following.

The core AVI philosophy is to get the particle moving and into solution and then detect. Approach is not suitable alone for Amgen’s products or contaminants identified.

Especially for syringes which need a bigger $\omega$ to move the particles.

Particle Tangential velocity, $V_t = \omega \cdot r$
- Container rotation speed $\omega$
- Container radius $r$, $r(v) > r(s)$

Note: Fill volume has also a large impact on fluid dynamics.
Even with movement you have to make sure the movement does not lead to wavelet Reflections which can be seen as particles. 

**Side Note:**

Important to check when these issue happen if it's down to mimic solution.
The detection strategy for these types of particles especially when they fall inside the region 1,2,4.

[1] Cellulose
[2] Polyester
[3] Polyamide
[4] Hair
[5] Polypropylene
[6] Silicone
[7] Cotton fibre
[8] Nylon
[9] Polystyrene
other
POINT 2: Testing of the system. The last 4 slides are showing the initial areas of capability of a Vision System that need to be tested.
Section 2: Testing of the system.

**Key point**

If you go into final testing and your core objective is to achieve a positive Knapp test only without understating the key capability checks that are also needed to be made on your system then you are entering into a grey zone.

AVI to be equal or (slightly) better than MVI in terms of detection-→ successful knapp study.

**SUCCESSFUL TESTING:**

*KNAPP STUDY (As base line) + SYSTEM CAPABILITY CHECKS*
Conclusions  2 sections

• What are the critical items in a URS for a AVI system.  
(We have shown clearly the industry is specifying in the wrong areas.)

• Vendors have suffered some common ailments. We are supporting with the cure.  
(Initially some pain but vendors have improved their core vision components.)

• Critical Design improvements in our AVI systems.  
( New systems coming online are improved. But more steps to go.)

• How do we test our systems after these improvements. Knapp studies only?  
(Knapp approach alone is not enough to confirm capability. )
When you are specifying a Vision system specify the Vision Components you need.

Successful Testing

Knapp Study (As base line) + System Capability Checks.

Thank You