Mastering AVI

Part9: Future trends in AVI

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PDA
Parenteral Drug Association

pda.org/2021visual

2021 PDA VISUAL INSPECTION FORUM

CONNECTING PEOPLE SCIENCE AND REGULATION

PRESENTED VIRTUALLY 14-15 APRIL

EXHIBITION: 14-15 APRIL
#PDAvisual

3

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PTC Team Members

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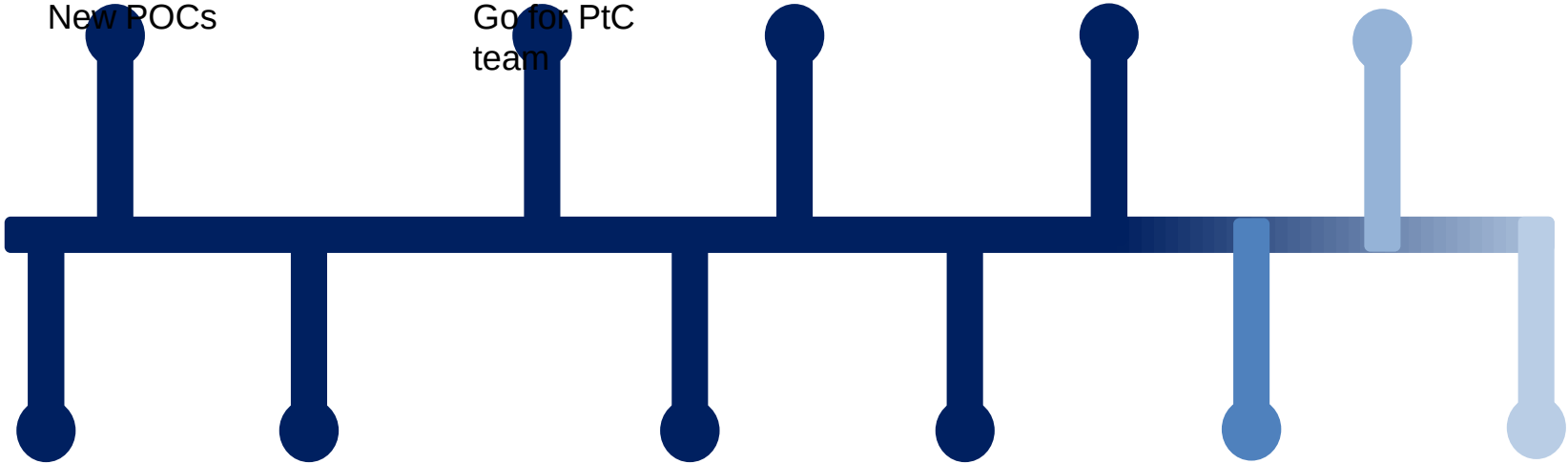
- Christian Eckstein, Data scientist MVTec
- Andrea Sardella, Stevanato Group
- Lars Aabye-Hansen, Novo Nordisk A/S
- Zheng Li, Genentech
- Jorge Delgado Torres, Amgen
- Chady Elahmad, MVTec

Inspection Timeline



Oct 2018
PDA Berlin
1st POC

May 2019
PDA Berlin
IG
AI talks

Feb 2020
Kickoff PtC team
Weekly call

June 2020
Document content defined

Dec 2020
1st Draft

Q4 2021
PtC PDA Publishing

April 2019
PDA Bethesda
New POCs

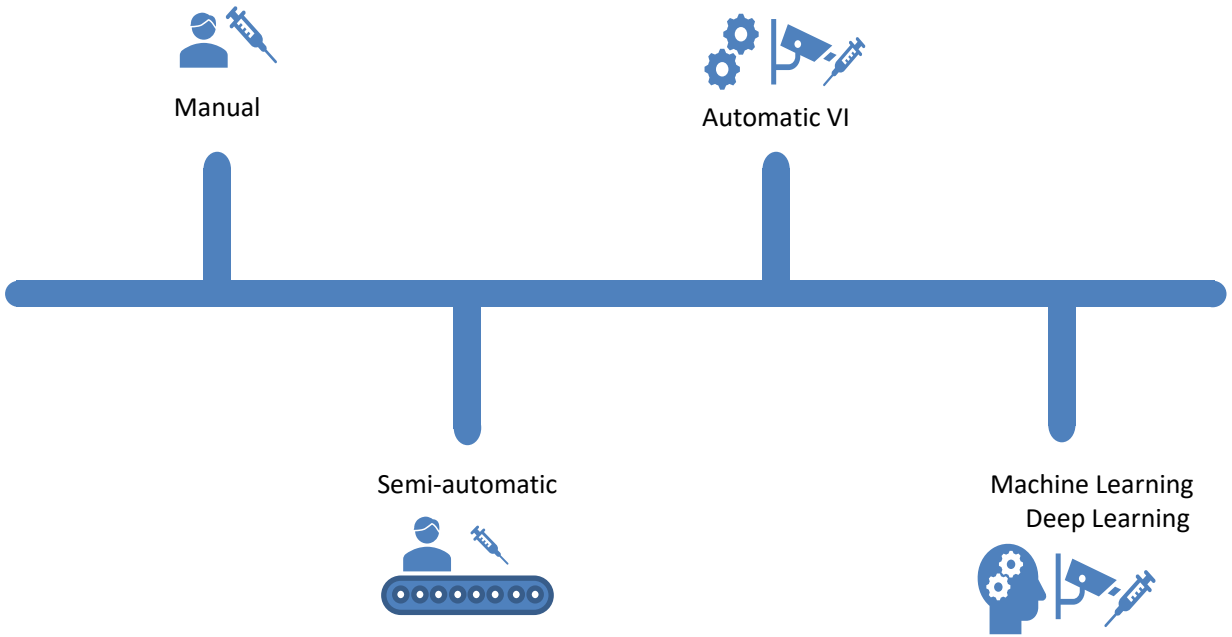
Dec 2019
PDA SAB Board
Go for PtC team

March 2020
Scope and target defined

Oct 2020
Presentation
PDA Berlin

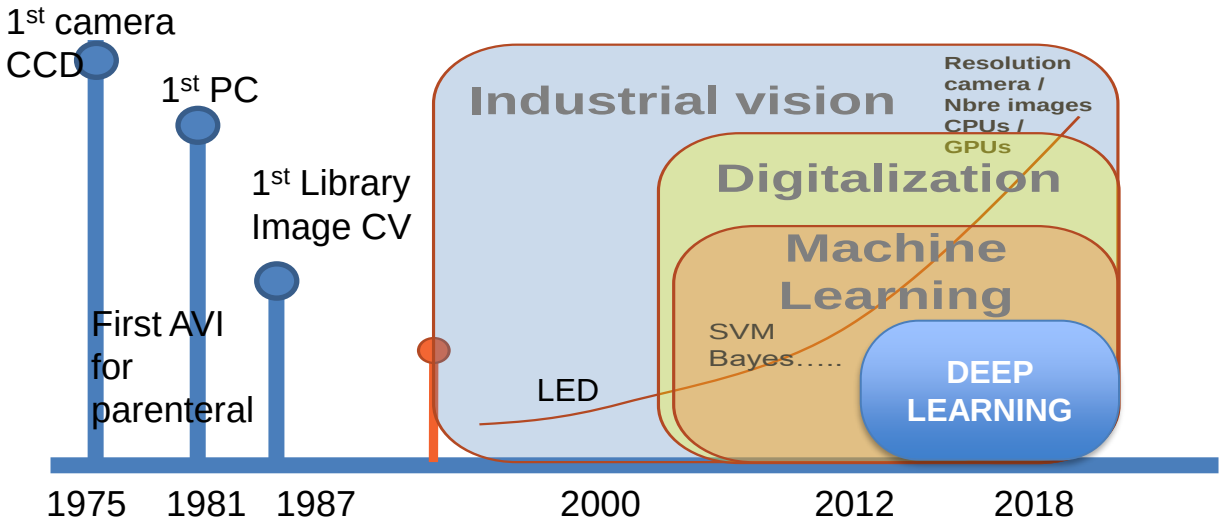
Q2 2021
PDA Board Reviewing

Where do we come from ?



- **AVI is a young, but maturing technology**
- **Many step changes over the last 30 years,**
- **next step change is AI**

AVI is a fast evolving technology



Key Take Away:

- AVI is a young, maturing technology
- Many changes over the last 30 years, next one is deep learning

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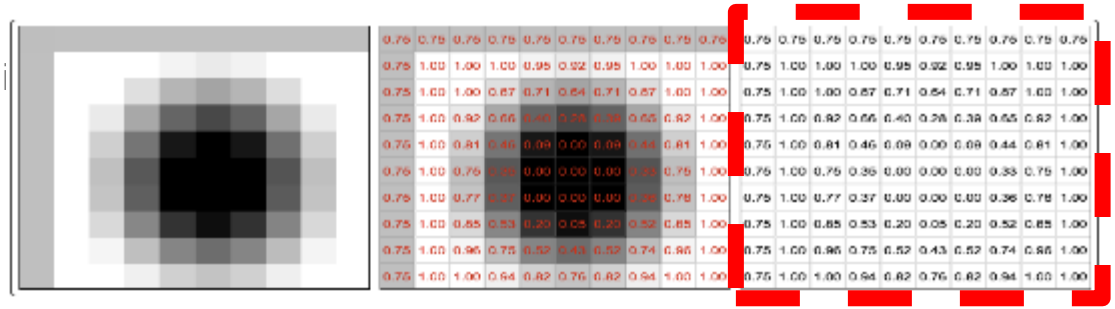
- What is a di



1 particle image

Image with grey levels…Digital Image = matrix grid of figures in X and Y

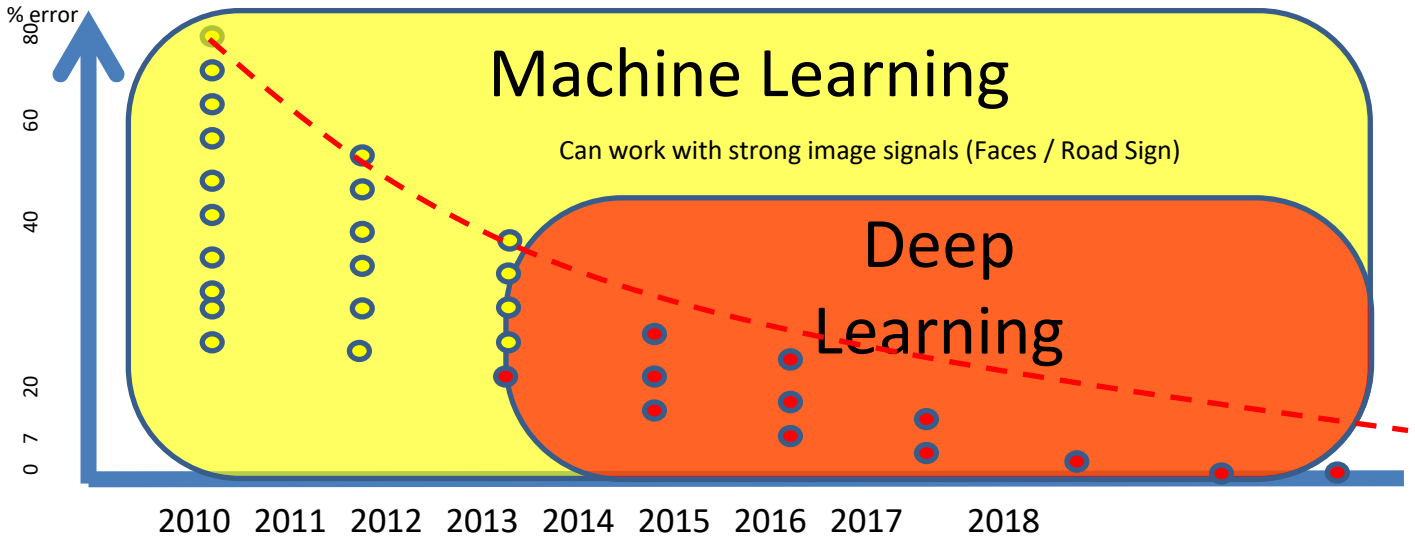
Key Take Away:

- **Computer vision see only a matrix**
- **That represent spatial distribution of grey levels**
- **Neural Network will work with image matrix**

In computer vision language (python/C++) it is a matrix object:

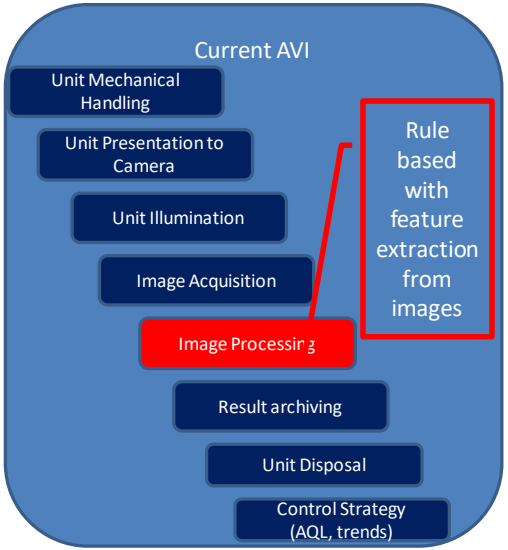
np.zeros(img.shape, dtype=img.dtype)

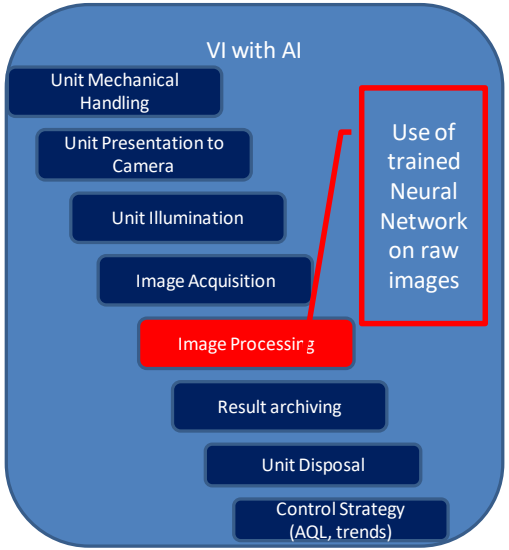
Machine Learning versus Deep Learning ?



Key Take Away: **Machine Learning (SVM) never achieved promising results with parenteral**

Current AVI versus machine Learning

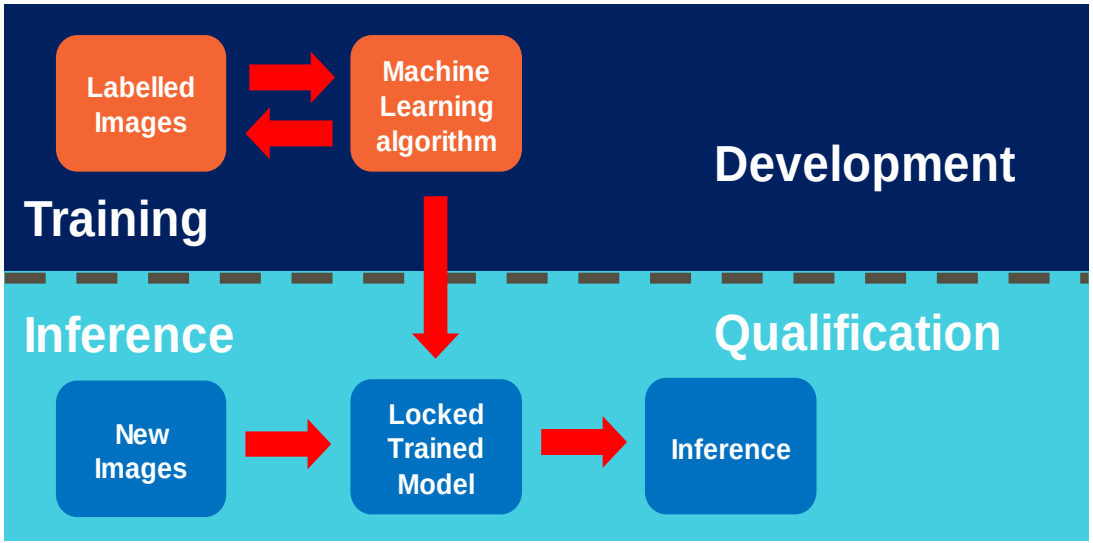




Point to consider:

- ❑ Scope of change with AI deployment is limited to image processing, all other crucial element remain the same

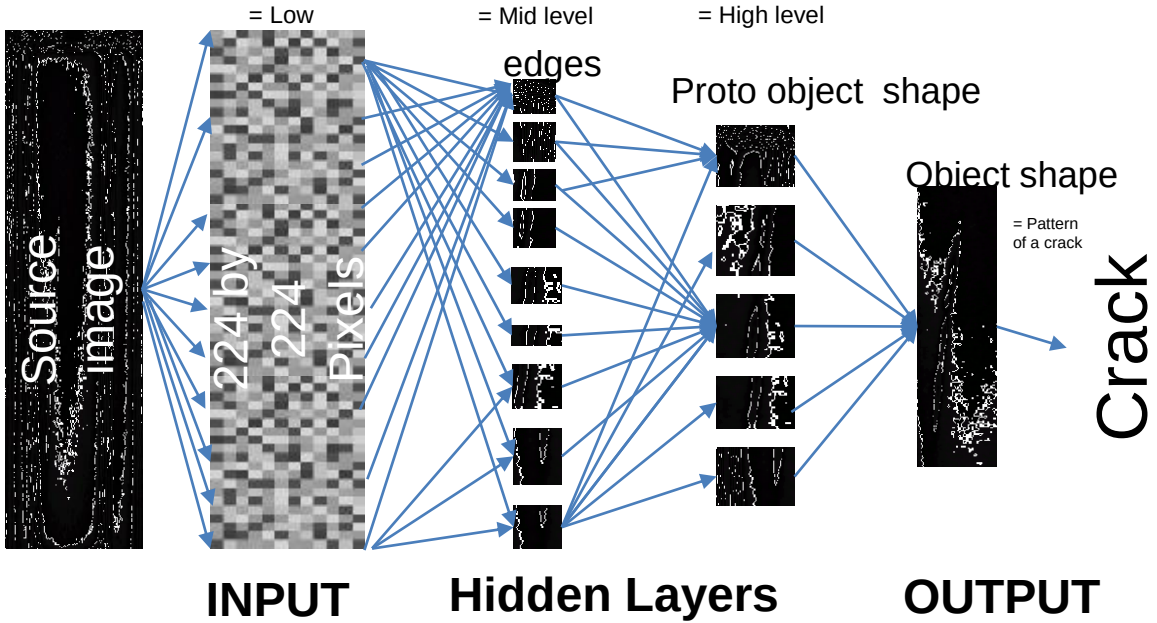
Principle of Deep Learning



Point to consider:

- ❑ with Supervised Deep Learning the vision set-up can be frozen and versioned before qualification and later use, it will not evolve, need for versioning control and audit trails

What is a Convolution Neural Network (DNN) ?

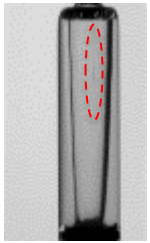


Key Take Away:
it is a NN dedicated to image treatment using convolution kernel filters
Pitfall with Neural Network is risk of overfitting on training images

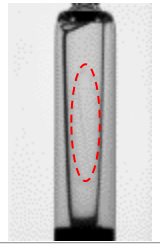
Image Labelling

Example of a binary detection between 2 classes: conform and crack

Conform (is a scratch conform?)

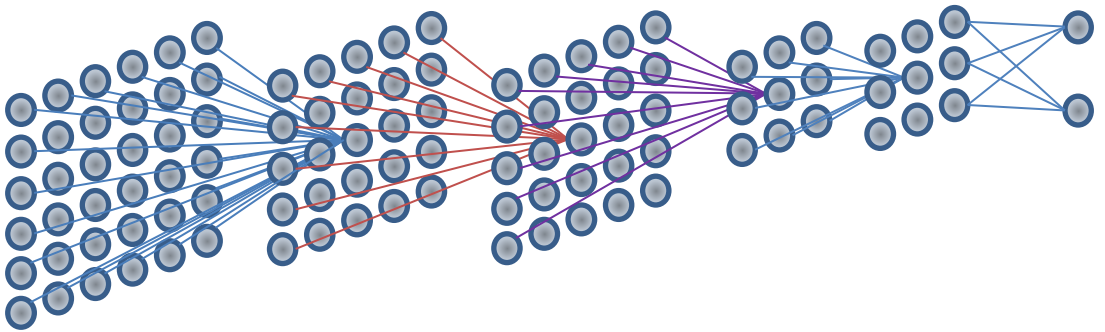


Crack

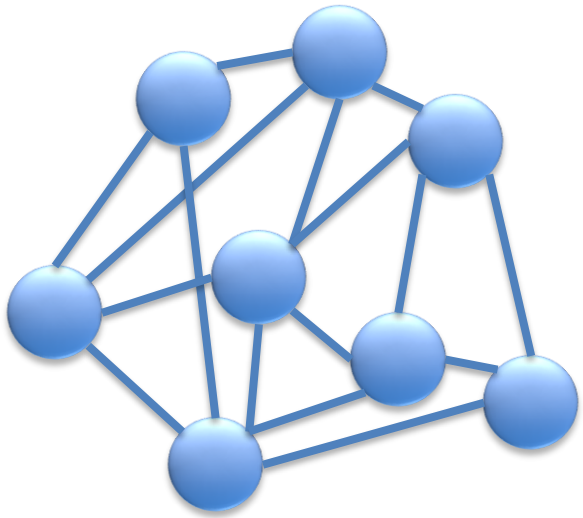


Point to consider:

- ❑ **Labelling defect per class is also very critical.**
- ❑ **Who can label an image ?**
- ❑ **How to document labelling ?**
- ❑ **What are boundaries of conforming class?**



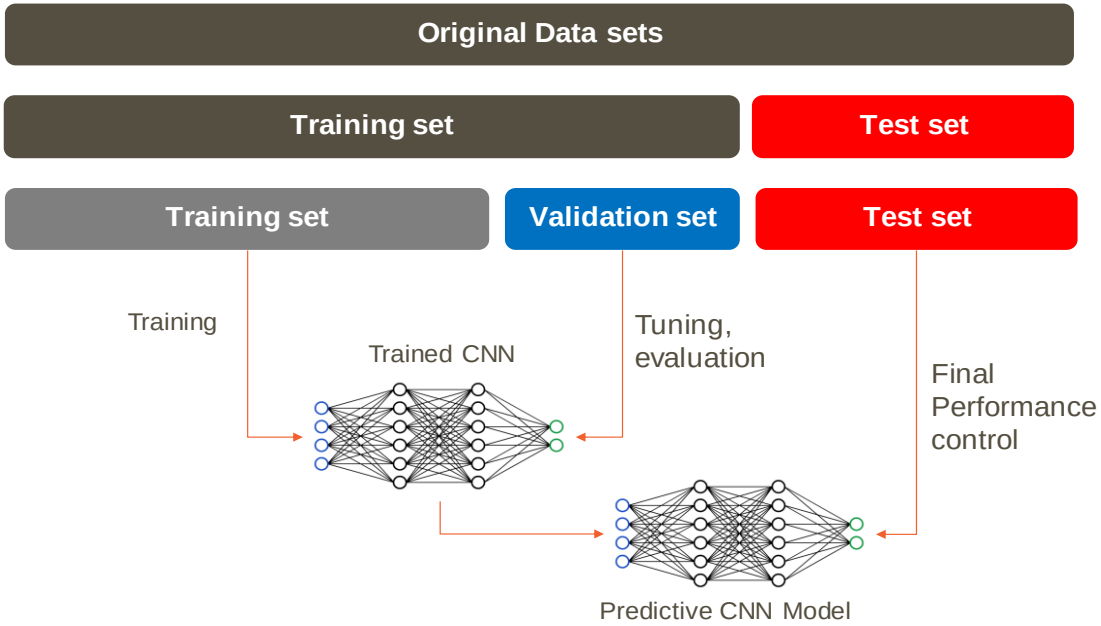
What are main points to consider to explore when moving to AI?



AVI with AI:

- ❑ Defect kit design space, explore grey zone
- ❑ Design space to the limit of unknown
- ❑ Image libraries for conforming unit class
- ❑ Defect labelling is a critical steps
- ❑ Vision engineers skills will remain
- ❑ Data science is new capabilities to develop
- ❑ Solid backend GMP IT infrastructure

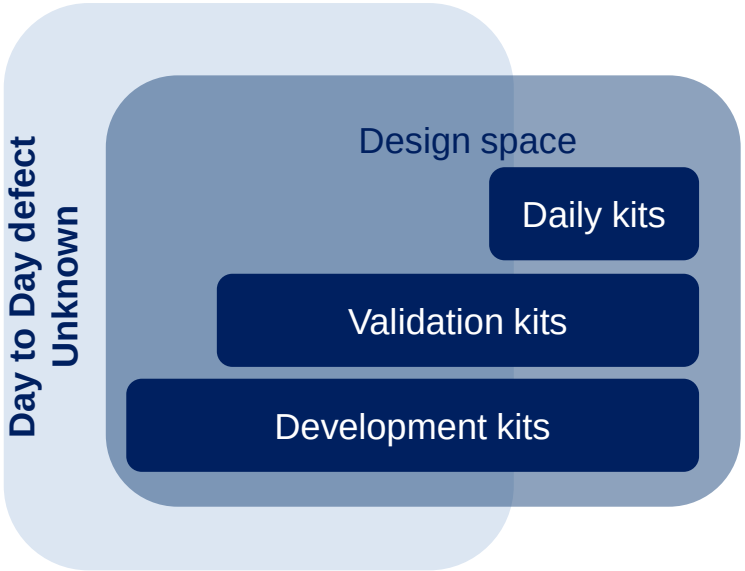
Image test sets



Point to Consider:

- Number of image per class is critical,
- the independence of training, validation and test set is critical,
- audit trail could prevent data leakage
- Proportion of each
- Number of images per class
- Augment image conditions
- Try to generalize from input images

Defect Design space

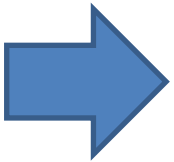


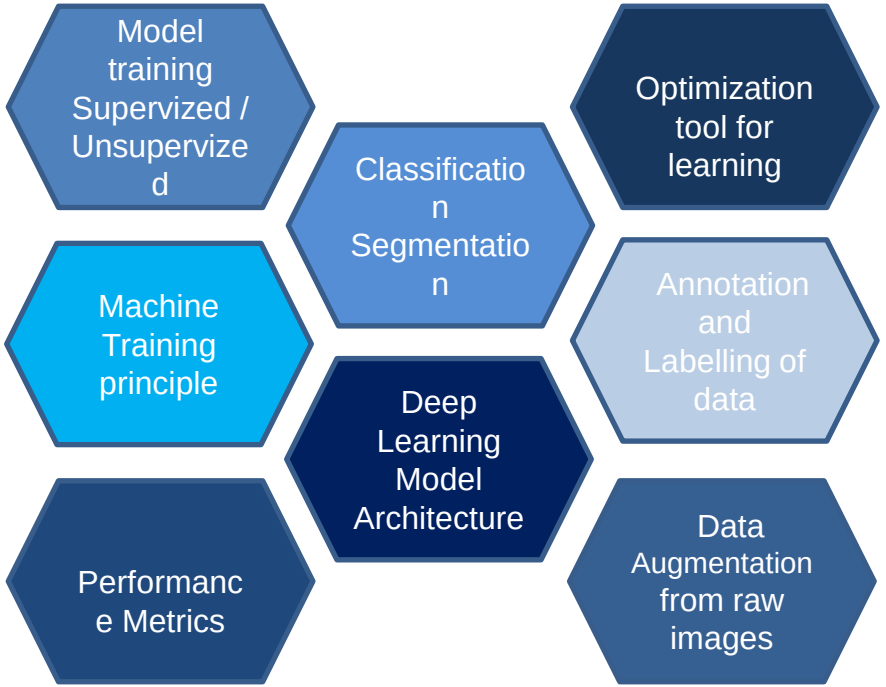
Point to Consider:

- ❑ **Risk to overfit on specific defect types and to have poor ability to the unknown**
- ❑ **The Design space should be extended to the maximal polymorphism of defect,**
- ❑ **The true defect zone may be too restrictive for AI development and training**
- ❑ **Need to explore to limit of the unknown, need more development kits to feed digital libraries**

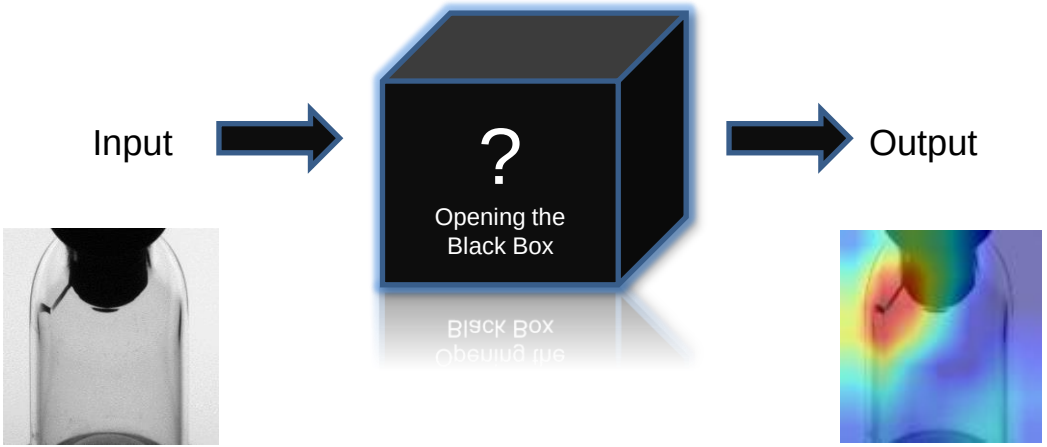
Key Data Science element to cover

Data Scientist Team
For solid scientific advisory





Why Visualization of results is so critical ?



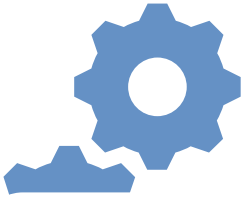
Point to consider:

- ❑ **it is key to report the results of AI with some visualization tools like heatmap, bounding box or segmentation to well document and give transparency**
- ❑ **Segmentation (SSD) can show where Deep Learning found a defects**

Validation of AI applied to VI

Desktop Qualification of ML

- Desktop performance evaluation
- Strong metrics documentation



On line performance evaluation

- Digital Image testing
- Real defect kit testing

Life cycle Continuous improvement

- Data gathering for improvement
- Continuous improvement with new validation of performance