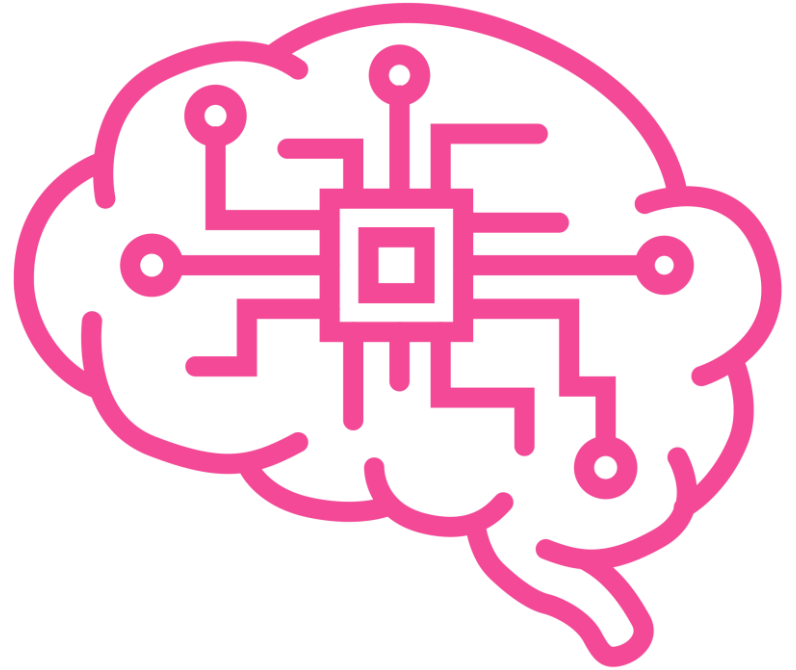


AI Gets Creative

Marta Mrak, Lead Engineer, BBC R&D



AI4TV @ACM MM 2019

21 Oct 2019

BBC | Research & Development



Introduction to BBC R&D

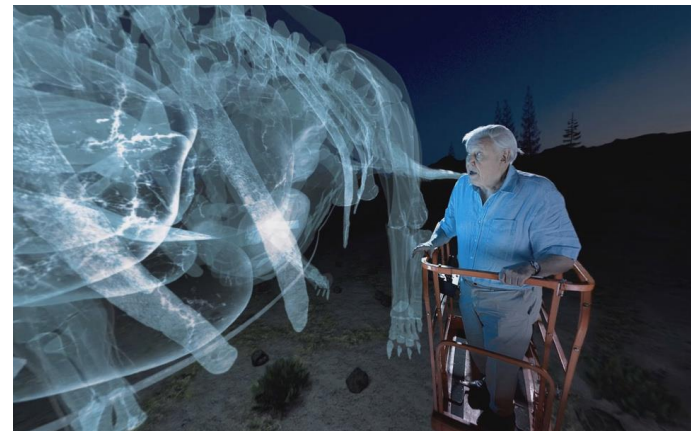


- UK public service broadcaster
- Oldest national broadcasting organisation (since 1922)
- Largest broadcaster in the world by number of employees
- Its content is also consumed all around the world
- It operates one of the most popular websites in Europe




- BBC R&D continues to provide the BBC with cutting edge innovations to help enhance their audience's experience
- At the moment includes around 200 engineers and scientist

- For over 60 years BBC R&D has played an integral part in shaping the future of broadcasting
 - Development of colour TV and High Definition to Freeview and Freesat
 - Fairest and highest quality broadcast innovations



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Venue Explorer

Venue Explorer is a prototype web application that lets viewers interactively explore an ultra-high-definition panoramic video of a live event, allowing them to zoom into areas of interest, with audio being automatically re-mixed to match the view. Graphical overlays can be...

Search BBC R&D
Explore our projects, publications and blog posts

Enter BBC, keywords, names

FRIGHT NIGHT

Fright Night

Special binaural headphone mixes of two cult horror plays for this Halloween on Radio 4

Our Vision of the Future

We will continue to lead the way in the development of a new broadcasting system with storytelling and IP at its core.

1944 - NOW

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AI & Auto Colourisation - Black & White to Colour with Machine Learning

Posted by Marc Gornik Blomch, *Media Week* on 24 Sep 2019, last updated 1 Oct 2019

Recent advances in deep learning have enabled the automation of many traditional production tasks that were the province of specialist technicians. Here at BBC Research & Development, we are researching how the quality of video could be enhanced by artificial intelligence and in particular how videos can be automatically colourised using some of the most recent breakthroughs in machine learning. As a result of our research, we are proposing a new and original algorithm that is capable of performing this task even more efficiently, making images and videos look more colourful and realistic.

How we used Isola and a ray microtomography to restore a severely damaged, and still remaining copy of an episode Morecambe and Wise's first BBC series.

Restoring Morecambe and Wise

How we used Isola and a ray microtomography to restore a severely damaged, and still remaining copy of an episode Morecambe and Wise's first BBC series.

BBC RemArc

Find out more about... and by the Remembrance Archive, which is designed to trigger memories in people with dementia.

Related posts

Video Coding at BBC R&D: From Research to Application

After HEVC compression was involved in development of the next generation of video coding standards, we've seen a lot of interest in the next generation of video coding standards.

Comparison of recent video coding technologies in MPEG

Research & Development

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Video Coding

Enabling a large amount of video data with limited bandwidth and high perceived quality.

BBC is famous for high quality content, stunning visuals and breath-taking pictures. So can we deliver the content at the highest possible quality to a huge number of viewers, making those with limited bandwidth?

Next from 2019 - present

Testing AV1 and VVC

After a year of work on a codec optimiser for streaming, processing time appears to be dropping significantly

Blog post on 18 March 2019

BBC R&D at IBC 2018 - Updates

"The world's most influential media, entertainment & technology show" has spent 4.5 weeks in Amsterdam - follow our updates.

Blog post on 14 SEP 2018

Video Coding at BBC R&D: From Research to Application

After HEVC compression we're involved in development of the next generation of video coding standards.

Blog post on 14 SEP 2018

Related projects

PROVISION

AI4TV

- Focus on the visual content
- Examples from content creation to content distribution



1. Content Creation, Archives



2. Auto AI Checks and Enhancements



3. Production Team Smart Select



4. Distribution

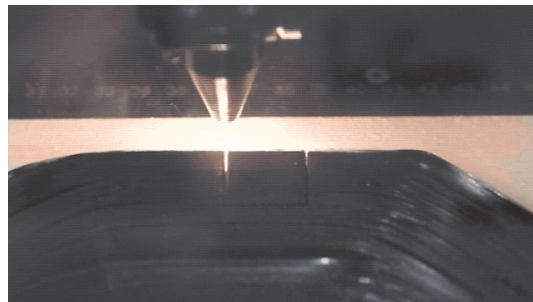
Example of visual content: Historical videos



- Historical videos:

- From videos in archives (> 1 million hours of playable material)
- To the content currently broadcasted

<https://www.bbc.co.uk/rd/blog/2017-12-morecambe-wise-video-film-archive-restoration>



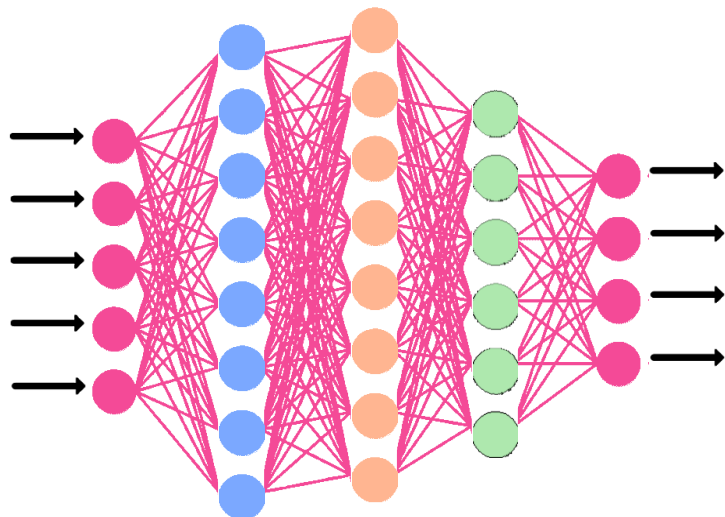
Example of visual content: user generated content



[Video not available in this version of the slides;
See <https://twitter.com/BBCRD/status/976781283627098113>]

Deep learning for visual content enrichment

Deep learning and visual data



- 50% of our neural tissue is related to vision
- Algorithms developed for visual data are very complex
 - But can help us with other data challenges
- Useful tool: 2D convolutions

- Artificial neural networks
 - Learning by adapting the neurons and connections between neurons based on training data
- Why now
 - Increase in data
 - Computing power

3 ₀	3 ₁	2 ₂	1	0
0 ₂	0 ₂	1 ₀	3	1
3 ₀	1 ₁	2 ₂	2	3
2	0	0	2	2
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10.0	17.0	19.0
9.0	6.0	14.0

An example of AI's perception of media using convolutions



block1_conv1

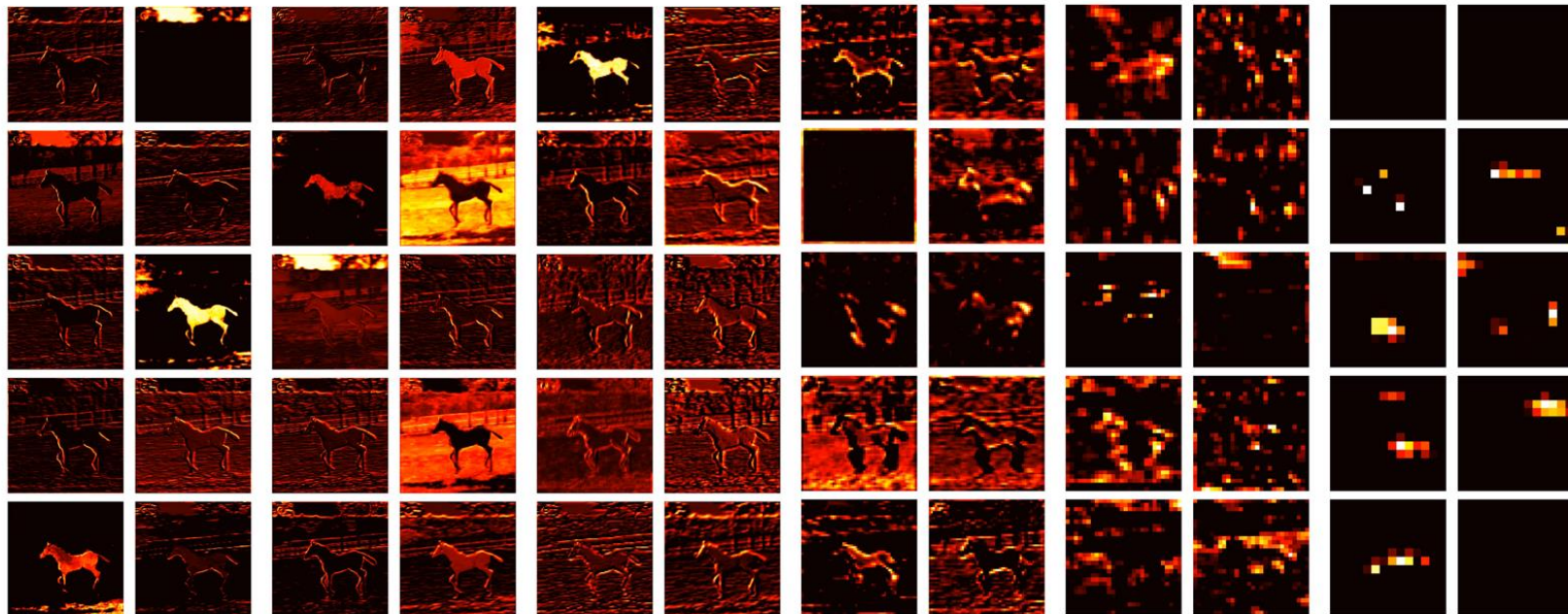
block1_conv2

block2_conv1

block3_conv1

block4_conv1

block5_conv3



[Video not available in this version of the slides]

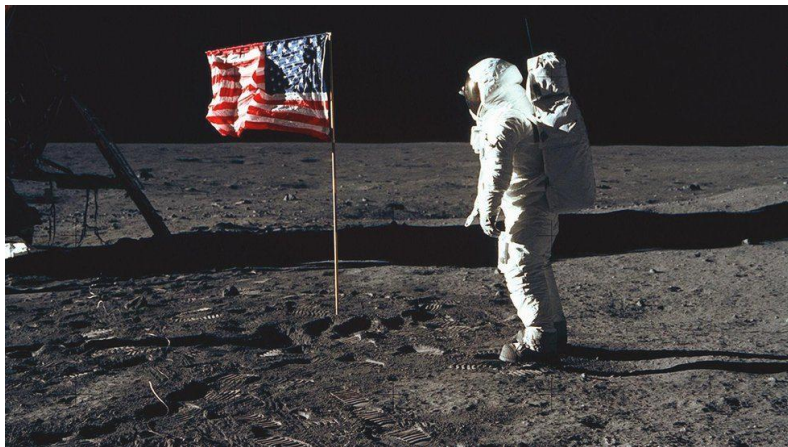
Enhancement of visual content



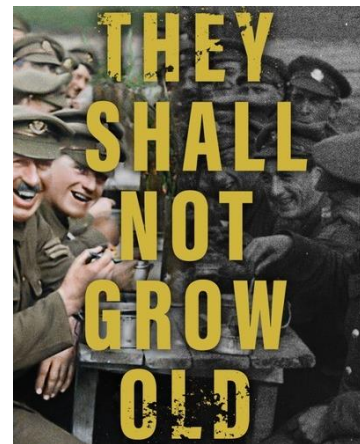
- Semantic enrichment
- Improve the appearance of images or videos:
 - Colour adjustment ✓
 - Sharpening
 - Inpainting
 - Deblurring
 - Denoising
 - Superresolution ✓
 - Perceptual enhancement
 - Artifact removal
 - Style transfer

Automatic image colourisation

- Introduced as a novel computer-assisted technology in 1970 for footages of the moon from the Apollo program missions



- Modern restoration techniques were used recently to colourise original footages of the World War I conflict, provided by BBC Archives and the Imperial War Museum



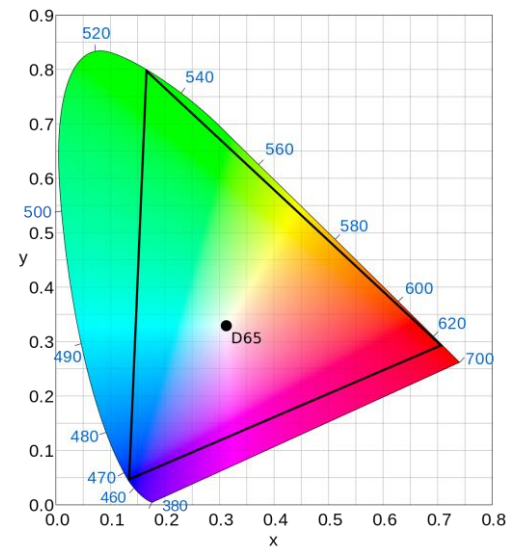
Colourisation methods

Semi-automatic

- ✓ Computer-assisted technology **improves the efficiency of traditional hand-crafted techniques.**
- ✗ Requires a considerable amount of **manual effort** and **artistic experience** to achieve acceptable results.

Automatic

- ✓ End-to-end techniques without involving manual effort.
- ✗ **Loss of precision** due to **inherent ambiguity** and **large degrees of freedom** possible in the task.
- ✗ Likely production of **desaturated results** due to **lack of generalisation in large databases of natural images.**



Automatic colourisation

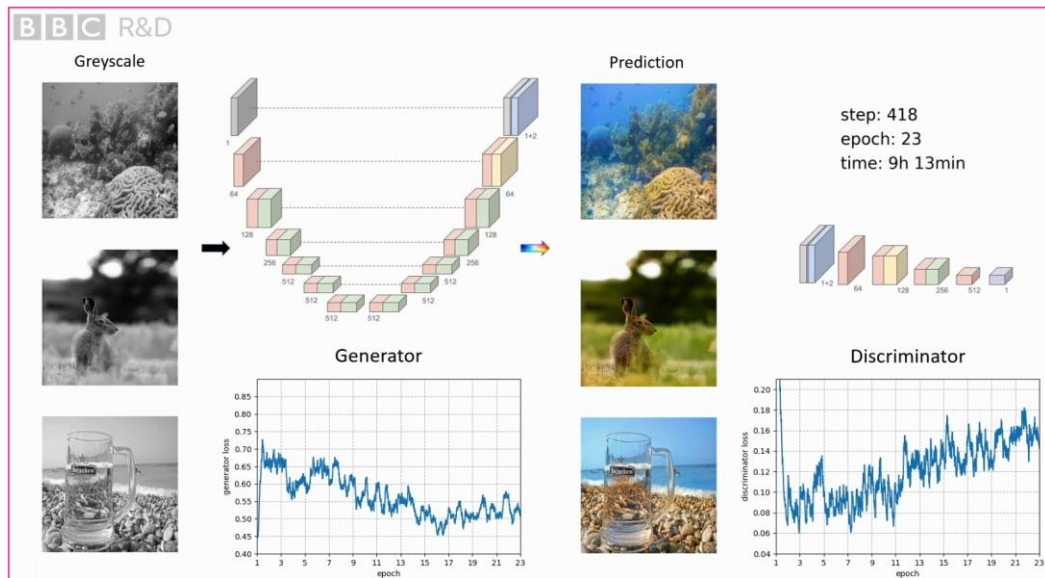


#jolt



Find out more

@BBCRD



[Video not available in this version of the slides; see <https://www.bbc.co.uk/rd/blog/2019-09-artificial-intelligence-colourisation-video>]

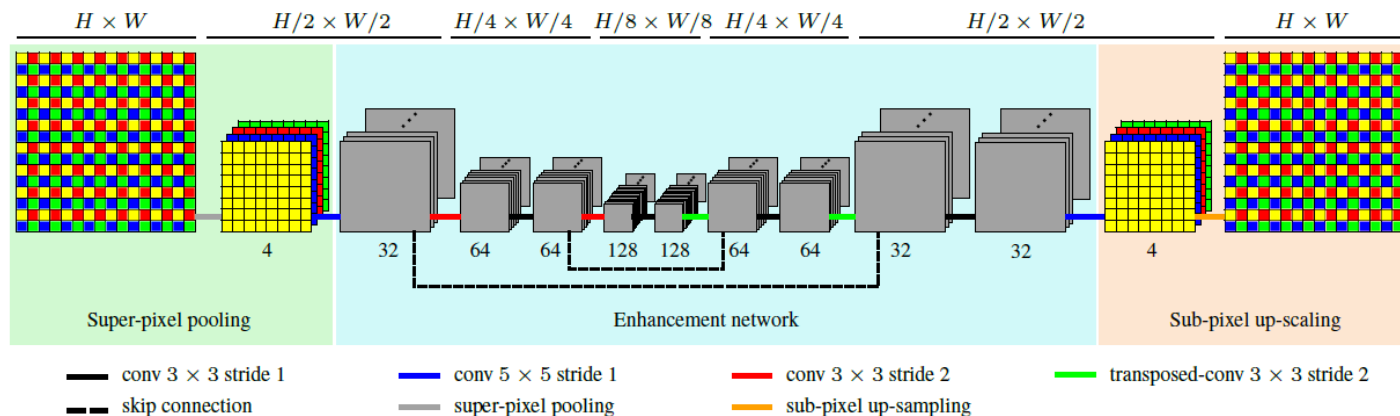
- Marc Gorriz Blanch et al., “End-to-End Conditional GAN-based Architectures for Image Colourisation,” IEEE MMSP 2019

Video enhancement: super-resolution



[Video not available in this version of the slides; see <https://www.bbc.co.uk/rd/projects/cognitus>]

Video enhancement: super-resolution



F. Toutouchi, and E. Izquierdo, "Enhancing Digital Zoom in Mobile Phone Cameras by Low Complexity Super-Resolution", IEEE ICME Workshops 2018 (ICMEW)

Semantic enrichment



The screenshot displays the COGNITUS web application interface. At the top left, the COGNITUS logo is visible. A navigation sidebar on the left includes 'Dashboard', 'Events', 'Plots', and 'Scheduling'. The 'Plots' section is active, showing 'All plots', 'My plots', and 'Create new plot'. The main area features a 'TIMELINE' with a video player showing a clip titled 'Hug the Bull' by John Burnett. Above the timeline are buttons for 'Play all', 'Play selected', 'Find similar', 'Audio correlations', 'Immersive sound', and 'Export EDL'. Below the timeline is a search section titled 'CONTENT ASSOCIATED WITH THIS EVENT' with filters for 'Search by text' (cardigan), 'Date range' (7/06/18 - 7/06/19), 'Creator' (All users), 'Status' (Enhanced vic), and 'Order' (Newer first). It shows 3 results for 'cardigan' with 'Enhanced' and 'Exclusive' tags. On the right, a 'FINAL VIDEO' section has an 'Upload final video' button and instructions to drag and drop a video.

[Video not available in this version of the slides; see <https://www.bbc.co.uk/rd/projects/cognitus>]

Video coding and AI

Video coding



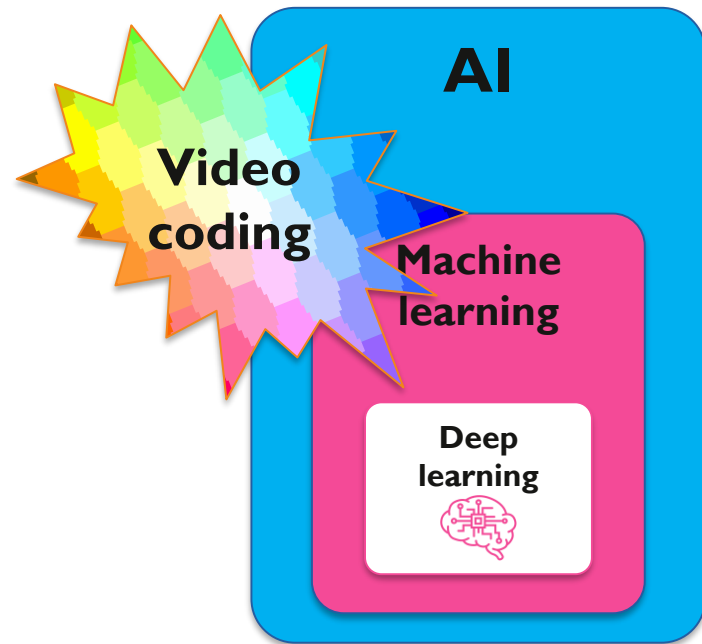
H.264/AVC
> 15 years old
Video streaming enabler



H.265/HEVC
> 5 years old
UHD / HDR streaming enabler



VVC (/H.266?)
Under development
Killer app?

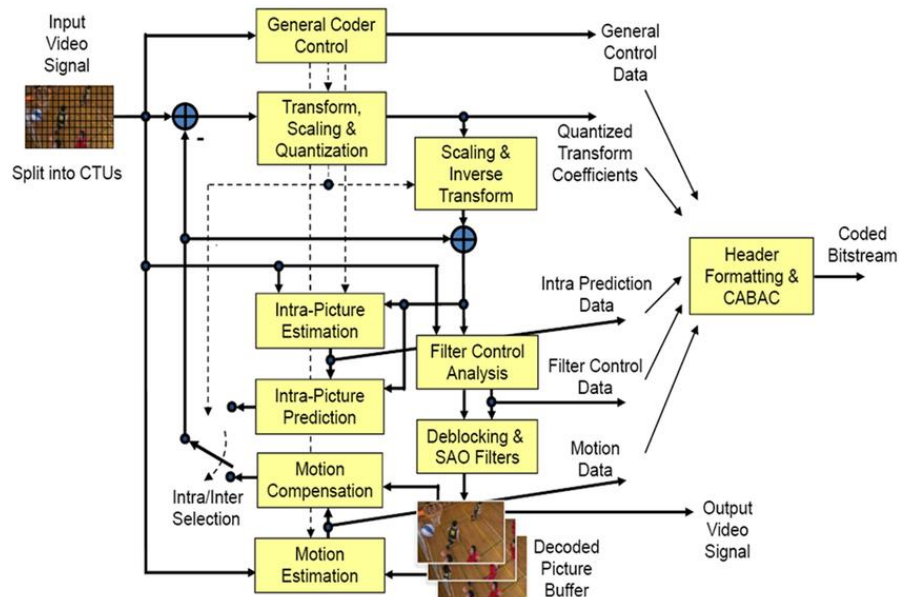


Video compression standards – building blocks

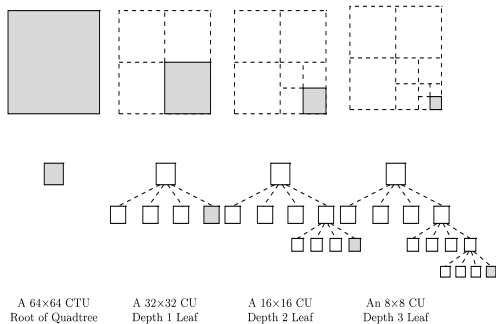
Video coding algorithms

- Signal processing
- Perception science
- Statistics
- Machine learning

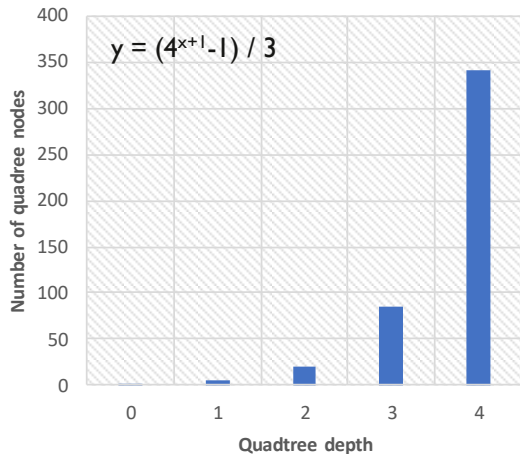
+ brute force



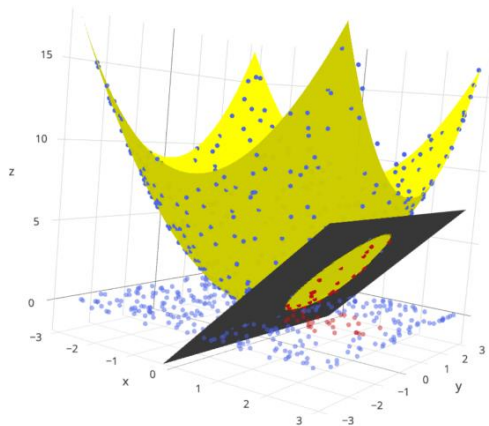
Applications of machine learning in video coding: reducing costs (or not)



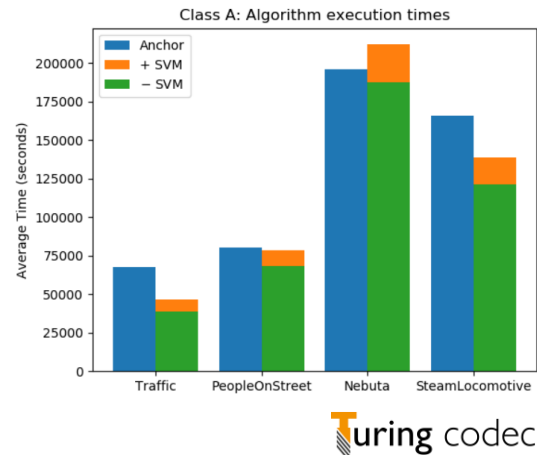
- **Brute force**
 - Check various split options, and pick the one that compresses given block the best
- **Required**
 - Reduce complexity of video encoder by reducing the number of split options that are checked
- **Hypothesis**
 - Reduction can be done using knowledge from the context



Applications of machine learning in video coding: Support Vector Machines

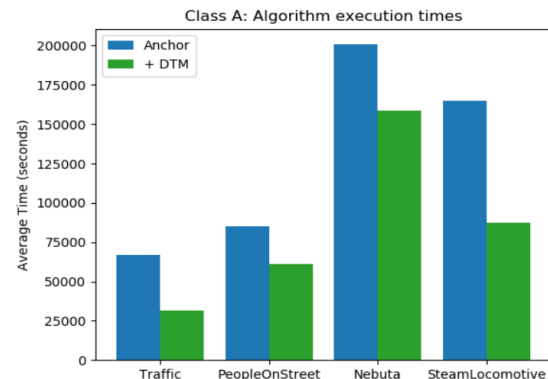
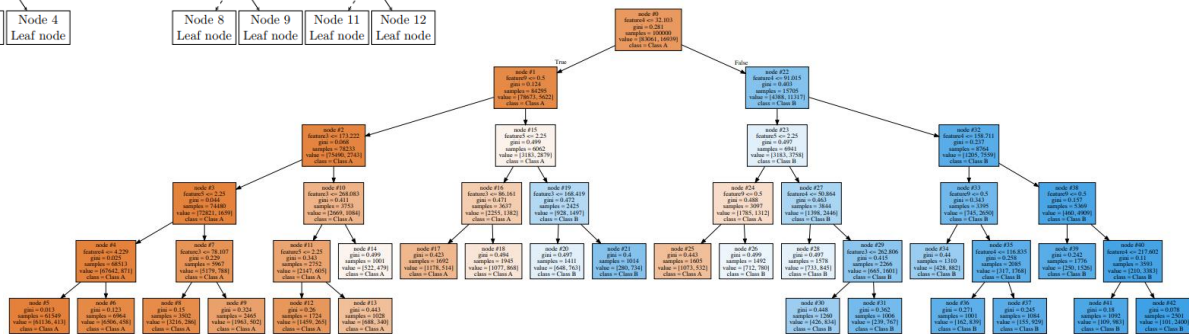
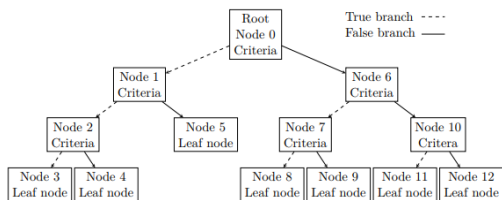


- Knowledge from the context filtered using SVM
- Reduced number of split options that are checked
- Reduced core encoder time ✓
- But...SVMs are costly
- Reduced overall cost ✗



Applications of machine learning in video coding: Decision Trees

- Decision trees – “glass box” approach
 - Determine optimised split decision structure

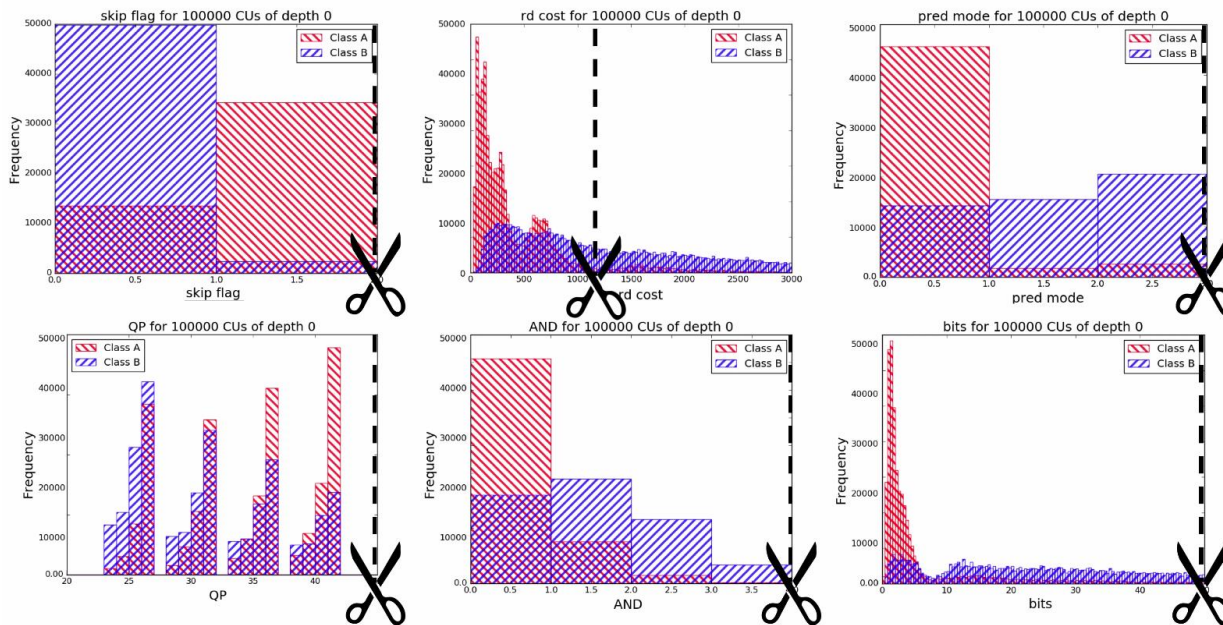


- Applied in HEVC and AV1 encoders
 - On average approx. 40% processing time saving, for less than 1% BD-rate loss

- Natasha Westland et al., “Decision Trees for Complexity Reduction in Video Compression,” IEEE ICIP 2019
- Jieon Kim et al., “Fast Inter-prediction Based on Decision Trees for AV1 Encoding,” IEEE ICASSP 2019

Growing of Decision Trees

Histograms of Coding Unit Features

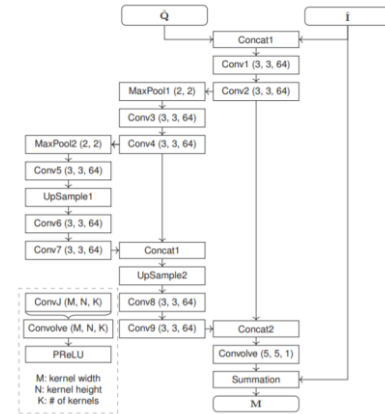
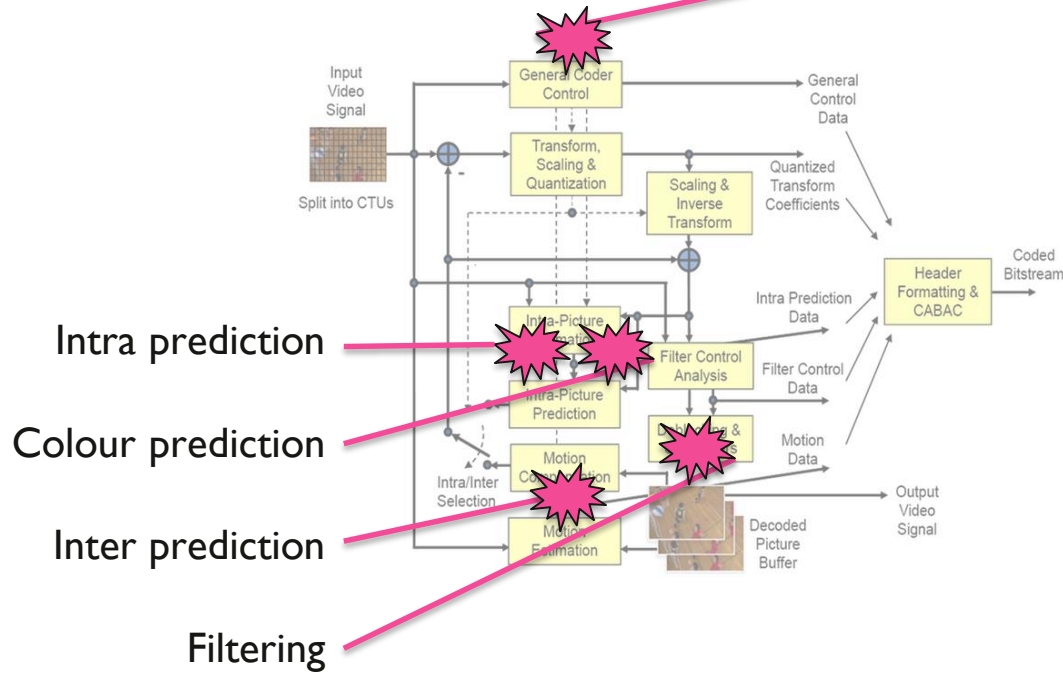


[Video not available in this version of the slides]



Examples of deep learning application in traditional video compression

Estimation of quality and bit-rate



- Maria Santamaria et al., “Estimation of Rate Control Parameters for Video Coding Using CNN,” in Proc. IEEE VCIP 2018

Video coding and ML: conclusions



[Video not available in this version of the slides]

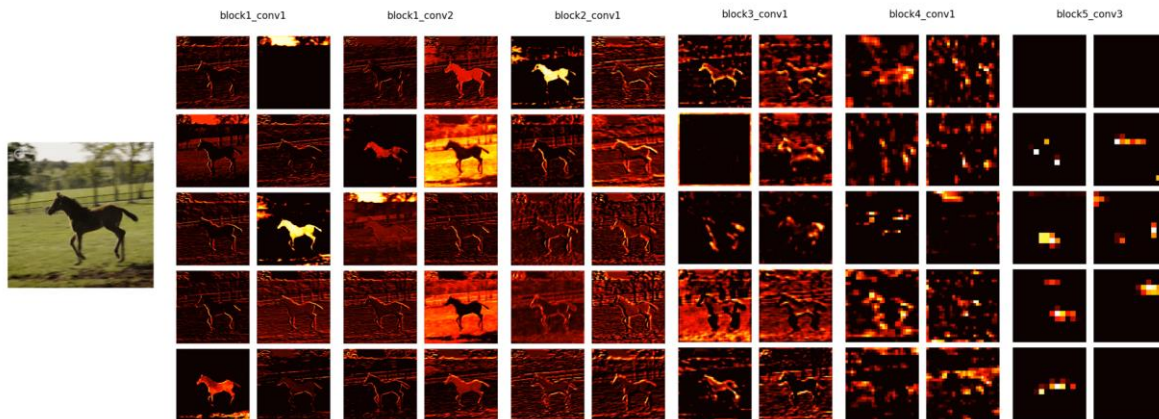
- For AI to be effective, algorithms have to be carefully designed
- Benefits:
 - Improved efficiency
 - Improved accuracy
 - Better decisions
 - Better predictions
 - Cost reduction
 - Quality improvement

Last but not the least

Beyond the power of data crunching



- The AI toolsets enable previously unachievable results
 - Embraced by the media sector
- However, there are also some negative consequences, e.g.:
 - Excessive use of computational power
 - Biases in AI systems
 - Manipulation, e.g. deepfakes
- Solutions
 - Deep technical understanding
 - Interpretability
 - Ethical use of data
 - Predictability



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9.0	6.0	14.0

Thank you
for your attention!

@martamrak

