

Big Data and Automated Content Analysis (12EC)

Week 13: »Multimedia Data« Friday

Damian Trilling

d.c.trilling@uva.nl, @damian0604

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UvA RM Communication Science

Today

Multimedia data

- The shift to wards multimedia data

- Representing multimedia data

- Classic SML

- Deep Learning

- (Commercial) APIs

Next steps

Today: Beyond words: Multimedia Data

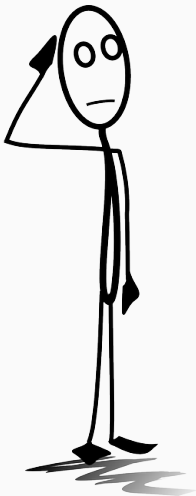
Multimedia data

Multimedia data

The shift to wards multimedia data

An old problem...

- Quantitative content analysis can be applied not only to text, but also to visuals (e.g., Bock et al., 2011)
- Not often done: labor intensive, (easy) data availability, ...
- Yet, more and more important in online settings (e.g., Araujo et al., 2020)



Maybe computational methods can help?

And yet, as we'll see, it's not that big a leap from what we already know!

Some examples

Chen et al., 2022

Can we detect conspiracy videos?

It seems we can, based (also) on visual features like contrast and brightness.

Techniques: Manual feature extraction + classical ML

Some examples

Jürgens et al., 2022

How are age and gender represented on German TV?

There seems to be discrimination against women and elderly

Techniques: Deep learning using pre-trained models

Some examples

Joo and Steinert-Threlkeld, 2022

How do politicians represent themselves visually in the media?

It seems there are party and gender differences

Techniques: Commercial API

[https://computationalcommunication.org/
ccr/issue/view/8](https://computationalcommunication.org/ccr/issue/view/8)

- moving images
- combining text and visuals
- really hot: Transformers¹ that model them simultaneously (!!!): “we present data2vec, a framework that uses the same learning method for either speech, NLP or computer vision. The core idea is to predict latent representations of the full input data” (Baeovski et al., 2022)

¹Think: a more fancy thing than embeddings that also takes into account that the same word can have a different meaning in different contexts



*But how do we do all of this? (not
data2vec, that's for another time...)*

Multimedia data

Representing multimedia data

Two types of pictures

Pixel graphics (also called bitmap or raster graphic)

- a matrix of pixels (\approx square dots) of a color
- therefore, losing quality when scaling (especially up)
- photos, screenshots, ...
- jpg, png, tiff, ...

Two types of pictures

Vector graphics

- geometric shapes
- therefore, fully scalable
- drawings, plots, ...
- svg, eps, ...

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Vector graphics

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We can easily convert vector graphics to pixel graphics – the other way around only approximately (or not at all)



*Not focus of today, but important:
How would you store graphs for a
report you want to publish?*



If pixel graphics are just a series of colored points, do we need something like the vectorizer we needed to transform words to numbers?

1. **Introduction**

Grayscale images

- If the picture is 200×300 pixel, we have a two-dimensional matrix with $200 \times 300 = 60,000$ pixels
- With a color depth of 1 byte = 8 bit = $2^8 = 256$, each of these pixels is an integer between 0 and 255
- **Two dimensions instead of one (for text)** – but we can *flatten* the matrix to a one-dimensional vector (“vectorize” it, if you want...) (in this case, of length 60,000)

Representing pixel graphics

Color images (RGB)

- Per pixel, we now have three color values (Red, Green, Blue) instead of one (Gray)
- Hence, our matrix becomes three-dimensional:
 $200 \times 300 \times 3 = 180,000$ integers between 0 and 255

- PIL (Pillow), the Python Image Library, provides many typical image operations (reading, displaying, cropping, color transformations)
- That's cool for batch processing (a for-loop and you can resize thousands of images...)
- But more importantly: **It's just a vector/matrix of integers, so we can do machine learning just like we did before!**

Multimedia data

Classic SML

First approach

- If each picture is just a vector of integers, scikit-learn works *exactly the same* as for survey data (Chapter 8) or text (Chapter 11).
- Typical example: recognizing hand-written characters with a Random Forest (Example 14.10) or a Support Vector Machine²

²https://scikit-learn.org/stable/auto_examples/classification/plot_digits_classification.html

This is impressive!

```

1 Classification report for classifier SVC(gamma=0.001):
2           precision    recall  f1-score   support
3
4      0           1.00      0.99      0.99         88
5      1           0.99      0.97      0.98         91
6      2           0.99      0.99      0.99         86
7      3           0.98      0.87      0.92         91
8      4           0.99      0.96      0.97         92
9      5           0.95      0.97      0.96         91
10     6           0.99      0.99      0.99         91
11     7           0.96      0.99      0.97         89
12     8           0.94      1.00      0.97         88
13     9           0.93      0.98      0.95         92
14
15    accuracy                0.97        899
16    macro avg           0.97      0.97      0.97        899
17    weighted avg           0.97      0.97      0.97        899

```

https://scikit-learn.org/stable/auto_examples/classification/plot_digits_classification.html



Can you explain why this works?

If the images are cropped and resized equally (!)...

...then the pixels in the center should be white for a 0 but dark for a 8.



Can you name tasks for which you think this would not work?

Multimedia data

Deep Learning



*Do you remember what the reason for
using deep learning in text
classification was?*

Say we want to recognize whether an image is a cat or a dog...

- Can we really say that the color of a pixel maps directly to the “catness” or “dogness” of the picture?
- Or should it not rather be about their fur, the shape of the ears, ...
- But it seems impossible to engineer these features by hand :-)

Let's use a deep neural network to learn them!

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Let's use a deep neural network to learn them!



Are you really seriously interested in classifying dogs and cats? There are many tutorials, e.g. here:

<https://machinelearningmastery.com/>

[how-to-develop-a-convolutional-neural-network-to-classify-photos-of](#)

How do we do this?

- For deep learning, we use `keras` instead of `scikit-learn`
- You need to specify the *architecture* of the network
- The process is resource-intensive

Different architectures

There are many..., but particularly interesting for us:

1. The multilayer perceptron (MLP): A fully-connected feedforward neural network (see Fig. 1)
2. The Convolutional Neural Network (CNN): Layers are not fully connected – think: regularized versions of MLP

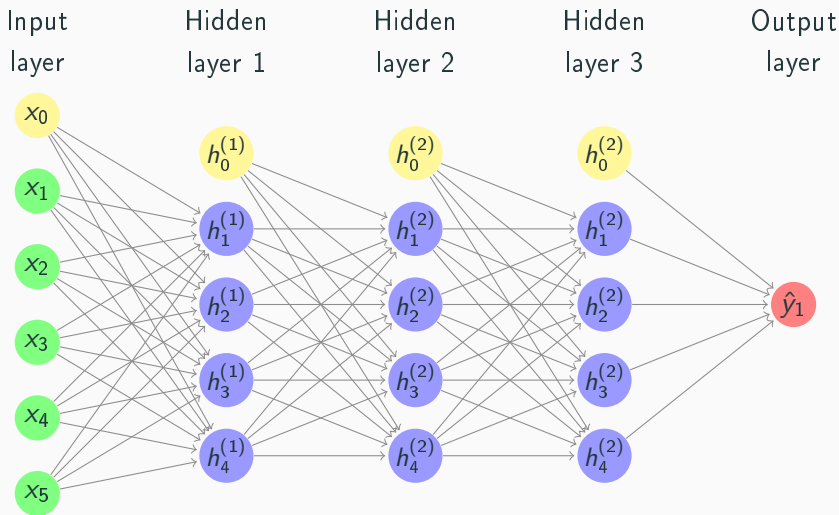


Figure 1: Architecture of a multilayer perceptron for binary predictions. The activation function of the output layer is the (logistic) sigmoid function; the other activation functions can be anything (e.g., ReLu)

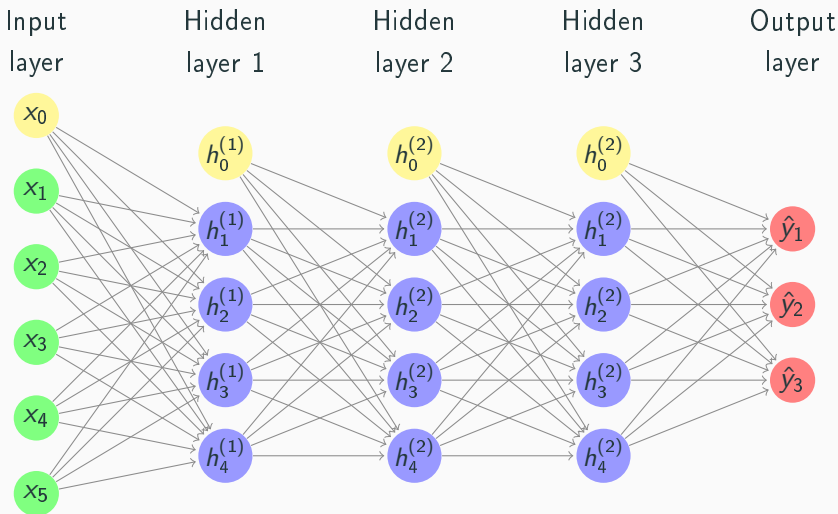


Figure 2: Architecture of a multilayer perceptron for multiclass predictions. The activation function of the output layer is the softmax function (like logistic, but probabilities add up to one); the other activation functions can be anything (e.g., ReLu)

Convolutional Neural Networks

- You start with a convolution layer
- A convolution is a mathematical operation on two functions³
- Think of it as a filter (say, sized 5×5 pixels) that slides over the image
- The result goes through a pooling layer that aggregates the outcome (e.g., using the max)
- Optionally: More convolution and pooling layers
- Finally, one or more fully-connected layers

³cross-correlation with one of the functions mirrored around the y-axis

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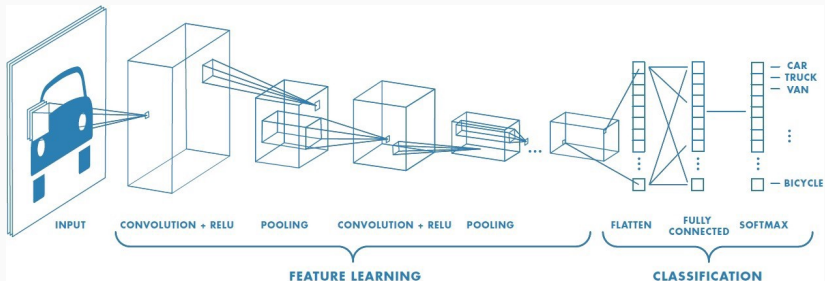


Figure 3: Architecture of a convolutional neural network. Source: <https://towardsdatascience.com/a-comprehensive-guide-to-convolutional-neural-networks-the-eli5-way-3bd2b>

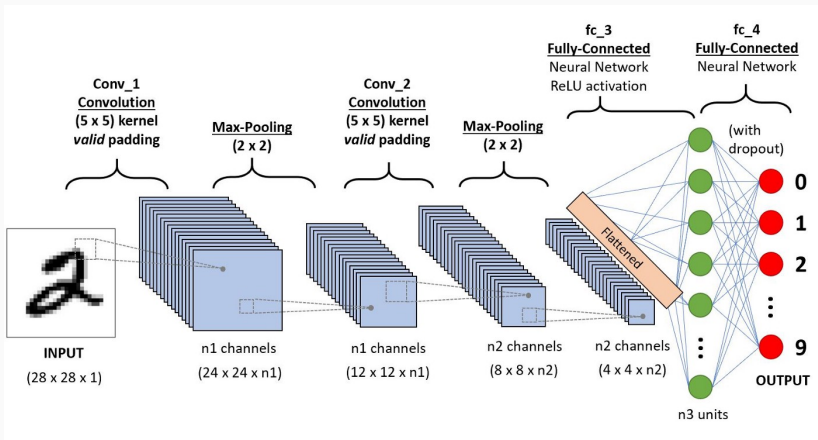


Figure 4: Architecture of a convolutional neural network. Source: <https://towardsdatascience.com/a-comprehensive-guide-to-convolutional-neural-networks-the-eli5-way-3bd2b>

- CNNs are more modern than MLPs and
- Because they integrate a *feature learning* step before the *classification* step, they need less preprocessing (Fig. 3
- CNNs are more resource-intensive to train

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Training your own neural network?

If you have a very specific task and an annotated dataset – sure!

But:

- Can be very resource-intensive
- Often, very large amounts of training data needed
- There are so many architectures, and you can't possibly know the best ones without being an expert

Training your own neural network?

Solution 0: Just do it ;-)

Training a MLP is not that difficult (Examples 14.11–14.14)

Training your own neural network?

Solution 1: Using a pre-trained model

Just use a CNN that already is trained (Examples 14.14–14.17).
Make sure to read up on the specific model you are using.

Training your own neural network?

Solution 2: Fine-tuning a pre-trained model

If you have a labeled dataset, you can start with an existing pre-trained model and then fine-tune it with your data (many tutorials online)

Training your own neural network?

Solution 3: A (commercial) API

(next section)

Multimedia data

(Commercial) APIs

What is it?

- You send an image to the API and get a set of labels back
- Under the hood: pre-trained neural networks
- Very much black box: you have no idea where the labels come from
- Prominent players: Clarifai, Google Cloud Vision, Microsoft
- Usually paid but often free for small projects and/or academic use

Automated Visual Content Analysis (Araujo et al., 2020)

Problem

The labels do not correspond what one may be theoretically interested in.

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Solution

- Annotate a set of images manually using a codebook
- Use the labels provided by the API as features to train a classifier to predict the annotations
- Thus, we essentially have transformed the image prediction task to a textual prediction task

Final remark

The black box nature of (most of) these techniques *is* a big problem from a social-science and epistemological point of view: in particular, known and un-known biases!

As always, but maybe especially here: Never take the outcome as a given – it needs interpretation and critical reflection!

Next steps

Let's have a look together at the course manual regarding the final project.

Examples

On Canvas under “modules”, you find some example projects. Note that these are not necessarily *perfect* assignments, and also that the content of the course (and hence, expectations) may not be fully identical to the year in which a specific assignment was made.

Friday

On Friday, you can *either* work on one of the computer vision examples discussed today and/or in the book.

Or you start working on your final project.

References



Araujo, T., Lock, I., & van de Velde, B. (2020). Automated visual content analysis (AVCA) in communication research: A protocol for large scale image classification with pre-trained computer vision models. *Communication Methods and Measures*, 14(4), 239–265.
<https://doi.org/10.1080/19312458.2020.1810648>



Baevski, A., Hsu, W.-N., Xu, Q., Babu, A., Gu, J., & Auli, M. (2022). data2vec: A General Framework for Self-supervised Learning in Speech, Vision and Language. *arXiv 2202.03555*.
<http://arxiv.org/abs/2202.03555>



Bock, A., Isermann, H., & Knieper, T. (2011). Quantitative content analysis of the visual. *The SAGE handbook of visual research methods*, 265–282.



Casas, A., & Williams, N. W. (2022). Introduction to the special issue on images as data. *Computational Communication Research*, 4(1). <https://doi.org/10.5117/ccr2022.1.000.casa>



Chen, K., Kim, S. J., Gao, Q., & Raschka, S. (2022). Visual framing of science conspiracy videos. *Computational Communication Research*, 4(1), 98–134.
<https://doi.org/10.5117/ccr2022.1.003.chen>



Joo, J., & Steinert-Threlkeld, Z. C. (2022). Image as data: Automated content analysis for visual presentations of political actors and events. *Computational Communication Research*, 4(1), 11–67. <https://doi.org/10.5117/ccr2022.1.001.joo>



Jürgens, P., Meltzer, C. E., & Scharkow, M. (2022). Visual framing of science conspiracy videos. *Computational Communication Research*, 4(1), 173–207. <https://doi.org/10.5117/ccr2022.1.005.jurg>



Webb Williams, N., Casas, A., & Wilkerson, J. D. (2020). *Images as data for social science research: An introduction to convolutional neural nets for image classification*. Cambridge University Press. <https://doi.org/10.1017/9781108860741>