



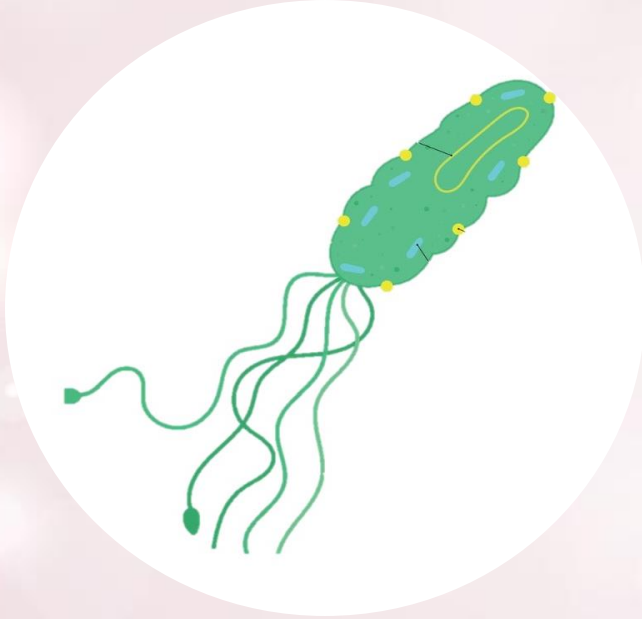
Machine-Learning-Guided Diagnosis for Helicobacter Pylori

Katharina Alexa Lang & Nico Enhardt, 7. Jan 2024

The background of the slide is a light pink color with a bokeh effect of white circles. Scattered around the edges are various medical-themed illustrations: a red and white capsule in the top left, a blue pill in the top center, a cluster of red pills in the top right, a red pill in the bottom right, a blue pill in the bottom right, a red pill in the bottom center, a cluster of blue pills in the bottom left, and a red pill in the bottom left.

Outline

- Motivation
- Convolutions in Image Processing
- Convolutional Neural Networks
- Results



Helicobacter Pylori

- Bacteria colonizes stomach
- 40% global incidence
- Often asymptomatic
- 10-20% develop ulcerus
- 0.5-2% develop stomach cancer

Diagnosis of H.pylori



Use case:

symptoms of stomach infection
or high genetic risk of stomach cancer



Methods:

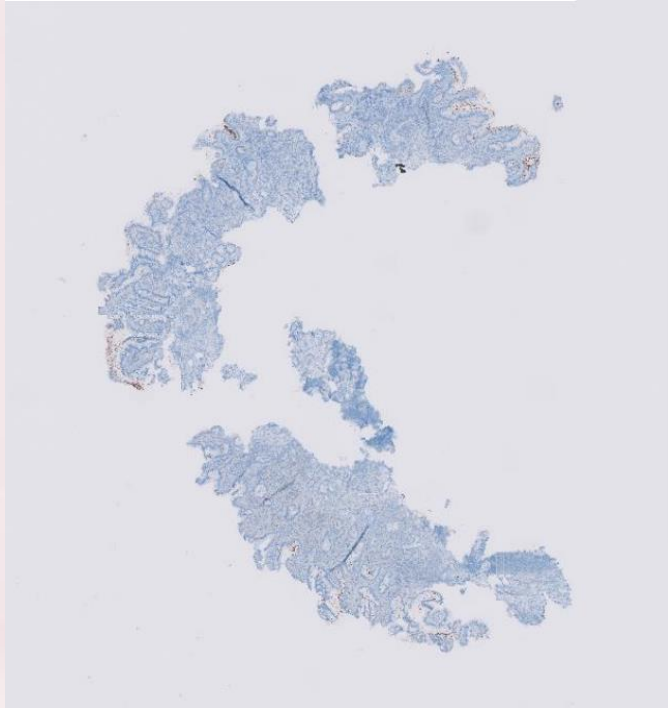
Stomach biopsy or antibody detection in blood



Treatment:

Patients receive antibiotics

Biopsy analysis is time consuming

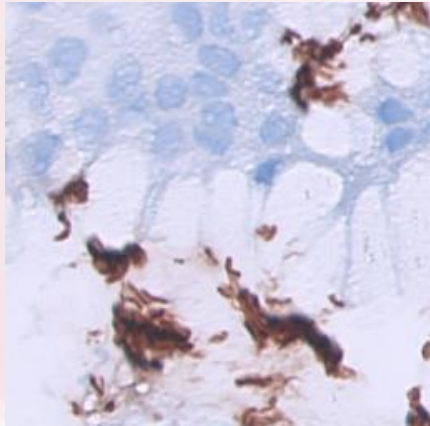


- samples of gastric mucosa
- very large images (120000 x 16000 pixels)

Biopsy analysis is time consuming

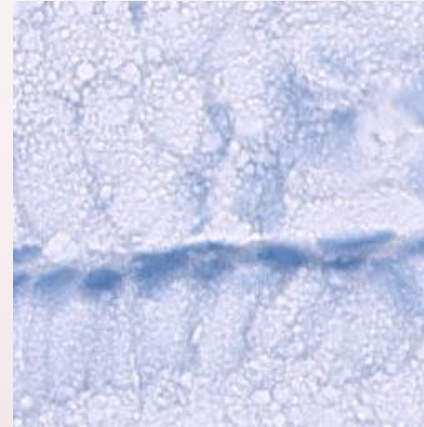
Infected tissue

Immunostained H.Pylori are visible as dark brown spots

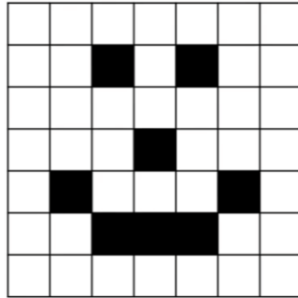


Healthy tissue

Tissue is free of H.Pylori



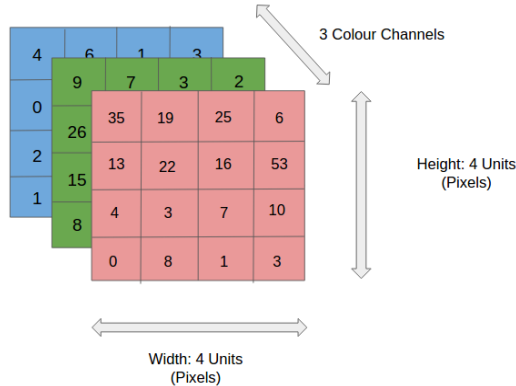
Pictures are just grids of numbers



| | | | | | | |
|---|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 1 | 0 | 0 | 0 | 1 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| 0 | 1 | 0 | 0 | 0 | 1 | 0 |
| 0 | 0 | 1 | 1 | 1 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 |



Pictures is grid of pixels. Each pixel contains number, eg for grayscale



Often >1 grid per picture to encode colour

Convolutional operations

original



convolved



Original image



Yellow pixels suppressed



Method:

Apply specialized filters (kernels) to each pixel

Function:

Extract features like edges, textures & shapes.

Mathematics of kernels

Source layer

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 5 | 2 | 6 | 8 | 2 | 0 | 1 | 2 |
| 4 | 3 | 4 | 5 | 1 | 9 | 6 | 3 |
| 3 | 9 | 2 | 4 | 7 | 7 | 6 | 9 |
| 1 | 3 | 4 | 6 | 8 | 2 | 2 | 1 |
| 8 | 4 | 6 | 2 | 3 | 1 | 8 | 8 |
| 5 | 8 | 9 | 0 | 1 | 0 | 2 | 3 |
| 9 | 2 | 6 | 6 | 3 | 6 | 2 | 1 |
| 9 | 8 | 8 | 2 | 6 | 3 | 4 | 5 |

Convolutional
kernel

| | | |
|----|----|---|
| -1 | 0 | 1 |
| 2 | 1 | 2 |
| 1 | -2 | 0 |

Destination layer

| | | | | | | | |
|--|---|--|--|--|--|--|--|
| | | | | | | | |
| | 5 | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |

$$\begin{aligned} &(-1 \times 5) + (0 \times 2) + (1 \times 6) + \\ &(2 \times 4) + (1 \times 3) + (2 \times 4) + \\ &(1 \times 3) + (-2 \times 9) + (0 \times 2) = 5 \end{aligned}$$

Examples of kernels

Original

$$\begin{bmatrix} 0 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 0 \end{bmatrix}$$



Blur

$$\frac{1}{9} \begin{bmatrix} 1 & 1 & 1 \\ 1 & 1 & 1 \\ 1 & 1 & 1 \end{bmatrix}$$

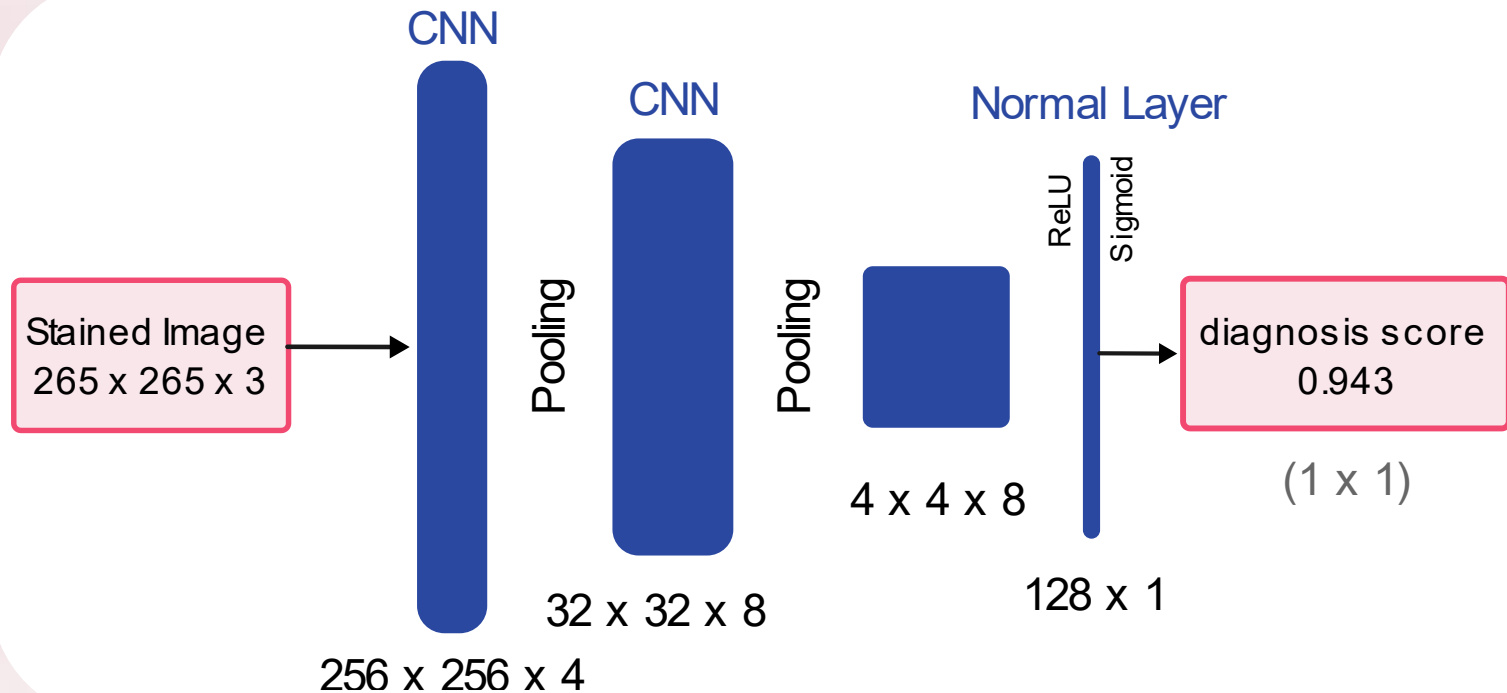


Edge Detection

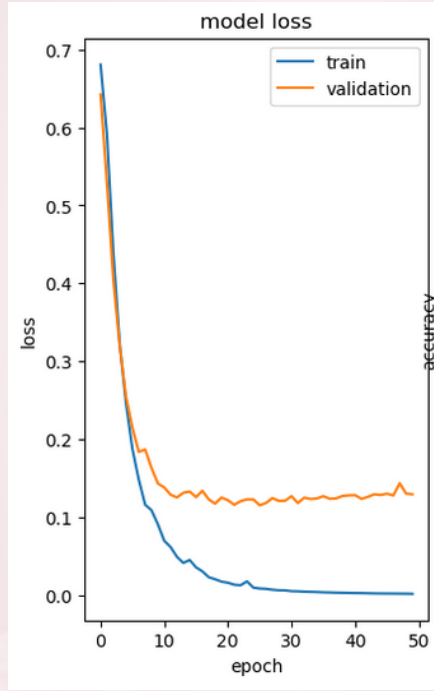
$$\begin{bmatrix} -1 & -1 & -1 \\ -1 & 8 & -1 \\ -1 & -1 & -1 \end{bmatrix}$$



Network Design



Training



<https://api.wandb.ai/links/rejio-universitat-aut-noma-de-barcelona/z8gdzvj4>

val_loss

— 20241115_190532_103716_4 — 20241115_190532_103716_3 — 20241115_190532_103716_2 — 20241115_190532_103716_1 — 20241115_190532_103716_0

Training



Training Results

- 2400 samples for training
- 600 samples for evaluation
- 120 patients for training
- 30 patients for evaluation

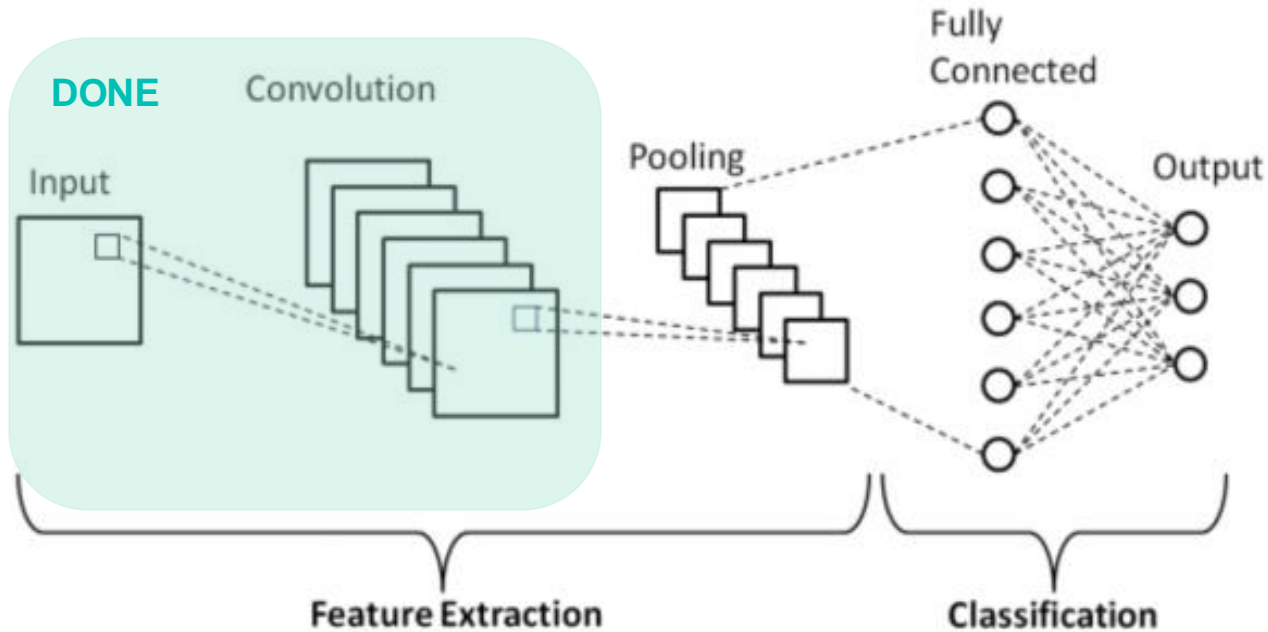
| [eval] | neg diagnosis | pos diagnosis |
|---------|---------------|---------------|
| healthy | 53 % ± 12 | 3,5 % ± 3,5 |
| sick | 2,4 % ± 1,1 | 41 % ± 10 |

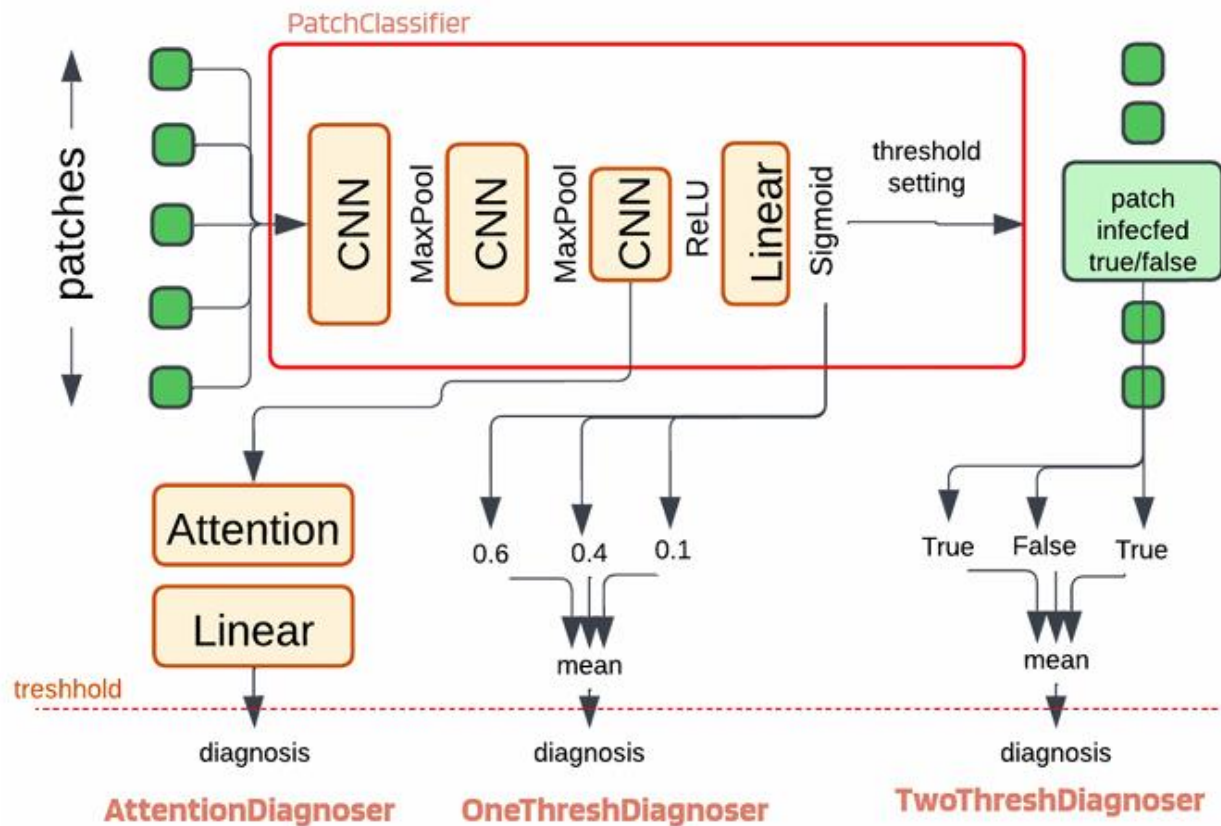
$$\frac{\text{correct diagnoses}}{\text{all diagnoses}} = 94 \% \pm 4$$

The background is a light pink color with a bokeh effect of white circles. Scattered around the text are several medical-themed icons: two blue capsules at the top, a red and white capsule on the left, a red and white capsule at the bottom, a cluster of red spheres in the top right, a blue virus-like sphere with spikes on the right, and a red virus-like sphere with spikes in the bottom right.

**Thanks for your
Attention**

Next: dimension reduction via pooling





| test-Cropped / HoldOut | Attention Diagnoser | OneThresh Diagnoser | TwoThresh Diagnoser | Distribution Diagnoser |
|---------------------------|---------------------------------|--------------------------------|--------------------------------|------------------------------------|
| Accuracy | 90% \pm 5% / 84% \pm 2% | 92% \pm 3% / 85% \pm 2% | 92% \pm 2% / 85% \pm 1% | 91 % \pm 3 % / 84 % \pm 2 % |
| Precision | 89% \pm 8% / 95% \pm 3% | 92% \pm 6% / 93% \pm 3% | 93% \pm 7% / 94% \pm 3% | 93 % \pm 8 % / 95 % \pm 5 % |
| Positive Recall | 92% \pm 5% / 73% \pm 4% | 92% \pm 4% / 76% \pm 3% | 91% \pm 4% / 75% \pm 3% | 88 % \pm 5 % / 73 % \pm 3 % |
| Negative Recall | 87% \pm 11% / 96% \pm 3% | 92% \pm 6% / 94% \pm 3% | 94% \pm 7% / 95% \pm 3% | 94 % \pm 7 % / 96 % \pm 4 % |
| F1 | 90% \pm 5% / 82% \pm 2% | 92% \pm 3% / 83% \pm 2% | 92% \pm 2% / 84% \pm 2% | 90 % \pm 5 % 82 % \pm 2 % |