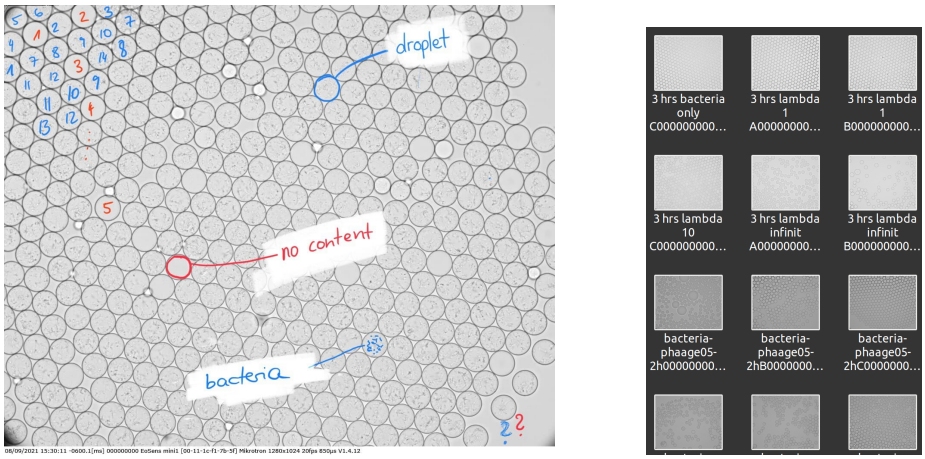

Figure 1: *(left)* Aqueous droplets dispersed in oil. Some contain bacteria cells. How many droplets are there? How many contain bacteria? *(right)* All examples look somewhat similar.

1 Cell/Particle Counting

Motivation There are various biological experiments, where the results of the experiment is analysed by counting cells or particles on an image. Some examples are: counting cells under the microscope to determine their concentration, counting bacteria colonies on agar plates or determine the size and occupancy of droplets. This happens frequently in everyday lab work and is manual labour! For example, Leonie spends a good time of her week counting these ;)

In this project you will help her and many others to make better use of their time than counting points on an image!

The Datasets We present two types of image particle counting problems, one of them more difficult than the other. The first is "Counting Droplets", the second is "Neubauer Chamber Automation".

(1) Counting Droplets.
In a microfluidic laboratory, experiments are performed in tiny water in oil droplets (around 5-100 μm diameter). For the success of the experiments it is crucial to determine the size and density of these droplets. For this purpose, a tiny portion of the emulsion is extracted, spread out on a glass slide and imaged under the microscope. Subsequently, the number of droplets in the field of view are counted and the droplet density is determined by eye.

Aqueous liquid is dispersed in oil and we want to

... count how many of the aqueous droplets are in the image.

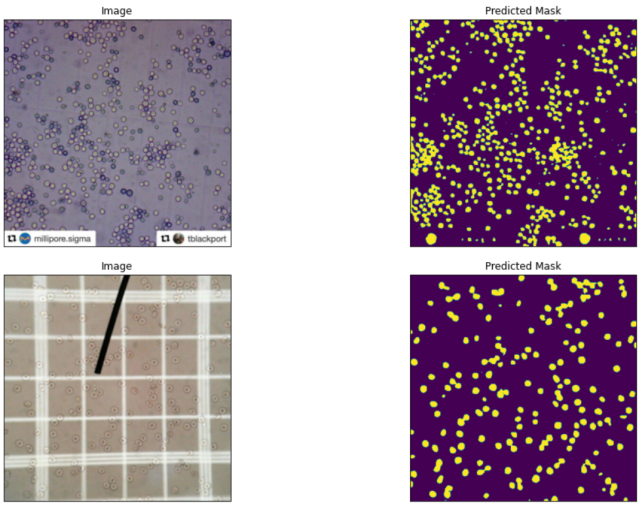

Figure 2: Another counting exercise: Different cells in hemocytometers with masked cells.

... how many of those contain bacteria cells.

... what the distribution of their diameter (in pixels) and volume are.

Example Fig. 1. Dataset contains 48 images but more could be obtained from the contact person this semester (but only same order of magnitude).

(2) Neubauer Chamber Automation.
A "device" that is often used in the lab is a hemocytometer (or Neubauer Chamber)[1]. Basically, it is a grid on a glass plate which is visible on microscopic scale and divides 2d space into squares to enable accurate density estimation. We collected a highly varied dataset of hemocytometer images with various particles under different conditions from instagram (people like to share the pain of their work online...) and annotated them. Its up for you to use them, you can see two examples in Fig. 2 and the variation of the dataset in Fig. 3!
We would like to know

... how many particles are in each image.

... given an example annotated patch of an image, find all other cells in the image (you will see that what is a cell/particle in the image can differ greatly).

The dataset contains 50 annotated images (particles are masked) and approximately 70 unlabeled images.

[1] `https://en.wikipedia.org/wiki/Hemocytometer`

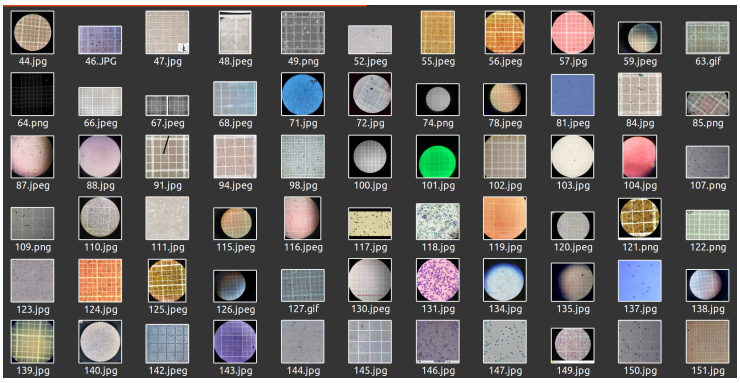

Figure 3: The Neubauer chamber dataset exhibits large variation in the setup of the microscope and cell types.

2 Some Related Work

Plain Cell Counting

- "EVICAN—a balanced dataset for algorithm development in cell and nucleus segmentation" [1][2]
- "Cell counting by CNN" (2016) [3]
- "Automatic object counting in Neubauer chambers." (2013) Barbedo [2]
- "A method of automatic cell counting based on microscopic image"(2013) Guo and Yu [3]
- "Method for counting microorganisms and colonies in microscopic images" Barbedo [4]
- "Image-based red cell counting for wild animals blood" Mauricio et al. [5]

Insipration

- "People, Penguins and Petri Dishes: Adapting Object Counting Models To NewVisual Domains And Object Types Without Forgetting" [4]
- "Class-Agnostic Counting" [6]
- "Class-Agnostic few-shot Counting" [5]

[2] https://edmond.mpdl.mpg.de/imeji/collection/l45s16atmi6Aa4sI

[3] https://link.springer.com/chapter/10.1007/978-3-319-46604-0_20

[4] https://openaccess.thecvf.com/content_cvpr_2018/papers/Marsden_People_Penguins_and_CVPR_2018_paper.pdf

[5] https://openaccess.thecvf.com/content/WACV2021/papers/Yang_Class-Agnostic_Few-Shot_Object_Counting_WACV_2021_paper.pdf

- "Counting Tomatoes" [7]
- "Learning to count objects" (2010) [6]
- "CANet: Class-Agnostic Segmentation Networks with Iterative Refinement andAttentive Few-Shot Learning" (2019) [7]
- Survey on instance segmentation (2020) [8] and github list of papers [9]

2.1 Public datasets

Annotated

- Dublin Cell Counting (Neubauer chambers!!) (177 items)[10]
  Includes stem cells derived from embryonic mice, isolated human lung adenocarcinoma and examples of primary humanmonocytes isolated from a healthy human volunteer
- "Segmenting Cell Nuclei" [11] (includes bounding boxes)

Without labels

- Simulated Fluorecence images [12]
- some huge collection of microscopy datasets [13] (including yeast)
- a collection of cell images... not all pratical but some include collections of cell cultures [14]

3 Contact

Freya Behrens (freya.behrens@epfl.ch)
Leonie Kolmar (leonie.kolmar@epfl.ch, Laboratory of biomedical microfluidics (LBMM)[15])

[6] https://papers.nips.cc/paper/2010/file/fe73f687e5bc5280214e0486b273a5f9-Paper.pdf
[7] https://arxiv.org/pdf/1903.02351.pdf
[8] https://arxiv.org/abs/2007.00047
[9] https://github.com/xiaomengyc/Few-Shot-Semantic-Segmentation-Papers
[10] https://github.com/markmarsden/DublinCellDataset
[11] https://www.kaggle.com/c/data-science-bowl-2018
[12] http://www.cs.tut.fi/sgn/csb/simcep/figures.html
[13] http://idr.openmicroscopy.org/cell/
[14] http://cellimagelibrary.org/images?k=blood&simple_search=Search&per_page=10&page=10
[15] https://www.epfl.ch/labs/lbmm/

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[1] Mischa Schwendy, Ronald E Unger, and Sapun H Parekh. EVICAN—a balanced dataset for algorithm development in cell and nucleus segmentation. *Bioinformatics*, 36(12):3863–3870, 04 2020. ISSN 1367-4803. doi: 10.1093/bioinformatics/btaa225. URL `https://doi.org/10.1093/bioinformatics/btaa225`.

[2] Jayme Garcia Arnal Barbedo. Automatic object counting in neubauer chambers. In *Embrapa Informática Agropecuária-Artigo em anais de congresso (ALICE)*. In: SIMPÓSIO BRASILEIRO DE TELECOMUNICAÇÕES, 31., 2013, Fortaleza.[Anais . . . , 2013.

[3] Xiaomin Guo and Feihong Yu. A method of automatic cell counting based on microscopic image. In *2013 5th International Conference on Intelligent Human-Machine Systems and Cybernetics*, volume 1, pages 293–296. IEEE, 2013.

[4] Jayme Garcia Arnal Barbedo. Method for counting microorganisms and colonies in microscopic images. In *2012 12th International Conference on Computational Science and Its Applications*, pages 83–87. IEEE, 2012.

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[6] Erika Lu, Weidi Xie, and Andrew Zisserman. Class-agnostic counting, 2018.

[7] Maryam Rahnemoonfar and Clay Sheppard. Deep count: Fruit counting based on deep simulated learning. `https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5426829/`.