

# Сегментация рукописного текста

**студент** кафедры ИОД (бывш. РИОТ)  
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**научный руководитель**  
Бегаев Артур

# 1 - Пояснение темы «Сегментация рукописного текста»

NOTE TO ALL APPLICANTS: If you do not submit the required documents or fail to submit required documents within the instructions, USCIS may deny your application.

## art 14. Interpreter's Contact Information, Certification, and Signature

Provide the following information about the interpreter.

### Interpreter's Full Name

Interpreter's Family Name (Last Name) Karim natural being Interpreter's Given Name (First Name) Ishammud va'id

Interpreter's Business or Organization Name (if any) V9. vitamin power ca

### Interpreter's Mailing Address

Street Name Mississippi Av, Green Building Apt. No. 195042  
City or Town United states of America, Toronto State Washington Zip 650  
Province DEI-MAC Postal Code 65042 Country Russia to India

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deviation. Per-pixel displacements are then computed using bicubic interpolation. Crop-out layers at the end of the contracting path perform further implicit data augmentation.

## Experiments

We demonstrate the application of the u-net to three different segmentation tasks. The first task is the segmentation of neuronal structures in electron microscopic recordings. An example of the data set and our obtained segmentation is displayed in Figure 2. We provide the full result as Supplementary Material. The data set is provided by the EM segmentation challenge [14] that was started at ISBI 2012 and is still open for new contributions. The training data is a set of 30 images (512x512 pixels) from serial-section transmission electron microscopy of the *Drosophila* first-instar larva ventral nerve cord (VNC). Each image comes with a corresponding fully annotated ground truth segmentation map for cells (white) and membranes (black). The test set is publicly available, but its segmentation maps are kept secret. An evaluation can be obtained by sending the predicted membrane probability map to the organizers. The evaluation is done by thresholding the map at 10 different levels and computation of the "warping error", the "Rand error" and the "pixel error" [14].

The u-net (averaged over 7 rotated versions of the input data) achieves without any further pre- or postprocessing a warping error of 0.0003529 (the new best score, see Table 1) and a rand-error of 0.0382. This is significantly better than the sliding-window convolutional network result by Ciresan et al. [1], whose best submission had a warping error of 0.000420 and a rand error of 0.0504. In terms of rand error the only better performing

- оцифровка документов

- распознавание текстов

- рукописный текст

- коллизии

- сверточные нейронные сети

- данные

# 1 - Цель работы

Разработка системы для сегментации рукописного текста с использованием алгоритмов машинного обучения

Особое внимание уделяется подготовке данных для машинного обучения

# 1 - Задачи

1. Изучение литературы по теме
2. Изучение архитектуры нейронных сетей для сегментации изображений и функций потерь, выбор и реализация подходящих вариантов.
3. Определение алгоритма подготовки данных, реализация системы подготовки данных (фреймворка) и подготовка данных для обучения.
4. Обучение моделей (алгоритмов машинного обучения) и измерение качества.
5. Тестовое применение модели на реальных примерах и анализ результатов.

# 1 - Актуальность работы

- Улучшение детекции и распознавания рукописного текста
- Устранение артефактов при генерации рукописного текста с помощью GAN
- Отсутствие открытого исходного кода по теме
- Отсутствие примеров реального применения

## 2 - Методы распознавания

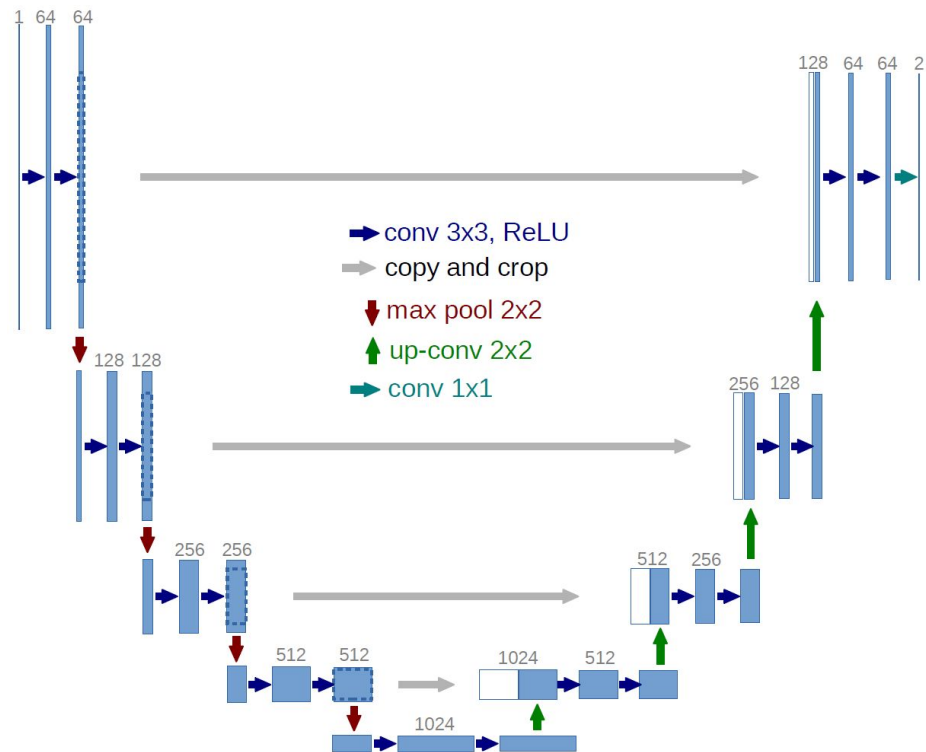
Сверточные нейронные сети

Сегментация =  
попиксельная  
классификация



## 2 - Методы распознавания

- U-Net
- Разная глубина сверток:
  - 16 - 32 - 64 - 128
  - 32 - 64 - 128 - 256
  - 64 - 128 - 256 - 512
- Вход – 1 channel (grayscale)
- Выход – 1 channel (hwr mask)
  - sigmoid



## 2 - Методы распознавания

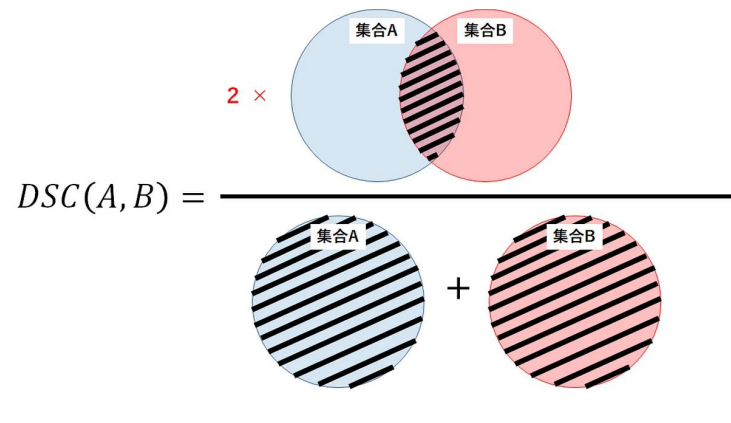
### Dice loss

$$D_p = \frac{2 \sum_{i,j} p_{i,j} m_{i,j}}{\sum_{i,j} p_{i,j} + \sum_{i,j} m_{i,j}}$$

где

- $p_{i,j}$  — это предсказанная вероятность для пикселя принадлежать к целевому классу (от 0 до 1)
- $m_{i,j}$  — значение маски в пикселе (от 0 до 1)

$$D_{binary} = F_1 = \frac{2 * TP}{2 * TP + FN + FP}$$





### 3 - Подготовка данных - подход

- Нет готовых наборов данных
- Можно сделать свой на основе рукописей и страниц печатного текста

### 3 - Подготовка данных - выделение фрагментов

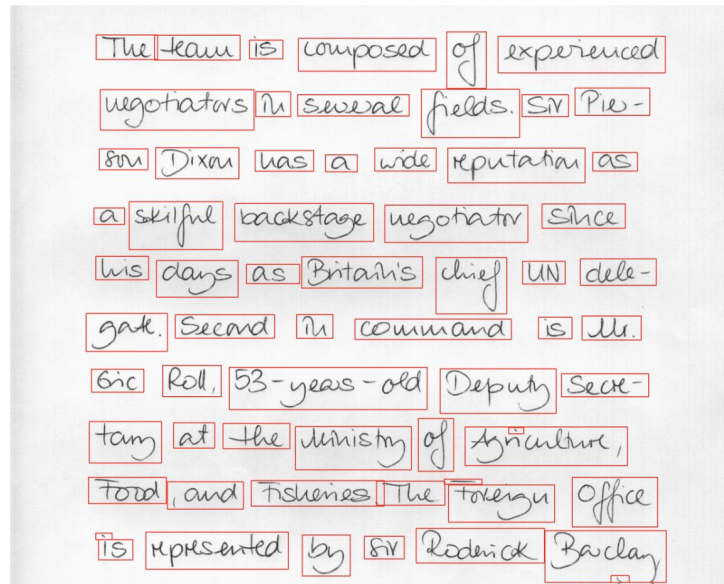
- Выделить слова и сохранить их как отдельные картинки
  - морфологические преобразования
  - findContours
  - отбрасывание выбросов
- Результат:
  - датасет IAM (2 100 страниц -> 47 000 фрагментов)
  - фреймворк для любых входных данных

endowed

That

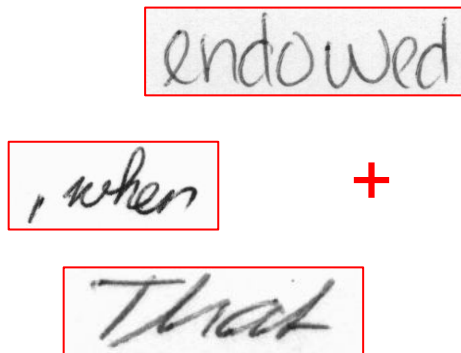
, when

too desperate for



### 3 - Подготовка данных - размещение

- Разделяем данные train/val/test
- Размещаем на каждой «печатной» странице 300 случайно выбранных фрагментов
  - случайное положение
  - случайный масштаб
  - случайный поворот



producing microfilariae of intermediate dimensions and periodicity [3]. (This is not to say that under natural conditions diurnally-periodic worms of human *Loa* are never transmitted to monkeys, but such events, if they do occur, appear to be rare).

Later, Belgian workers in the Mayumbe District in the south-western part of the Democratic Republic of the Congo (DRC), commented on the local human *Loa* infections in that area being particularly liable to give rise to cases of *Loa*-encephalopathy after treatment with diethyl-cabamazine citrate (DEC). They also noted that out of 547 patients from this area, whose blood films were examined both by day and night, 197 showed *Loa* mf only by day, 322 showed them by day and by night, and 16 showed mf only at night. Although the latter cases, with a complete reversal of the normal periodicity, showed only light microfilarial loads (12 cases with 1–5 mf per examination, and 4 cases with 6–9 mf per examination), among those persons who showed *Loa* mf by day and by night, 62 showed microfilarial concentrations that were nearly as high by night as by day and 10 showed more mf by night than by day (two of them showing 500 – 1,000 mf by night as compared with 300 – 500 mf by day) [4–6]. As some of the cases of loiasis from Mayumbe were abnormal in displaying a primarily nocturnal periodicity of the microfilariae, it is possible that the local strain of *Loa* responsible for them may be closely related to the simian parasite.

Recently in the Republic of Cameroon, cases of *Loa*-encephalopathy have been reported following mass treatment with ivermectin by the African Programme for Onchocerciasis Control (APOC) in areas where loiasis is co-endemic with onchocerciasis [7–11]. A remarkable clustering of many of these cases was found in the Léké Division, a forest and forest/savannah mosaic area some 80 km from the capital, Yaoundé. So far, the reason for this clustering has not become apparent but the occurrence of these cases of *Loa*-encephalopathy has had a deleterious effect on the popularity of the APOC campaign in that area [12]. Furthermore, at the end of 2003 in the Mayumbe area of the DRC, some 100,000 persons were treated with a standard single dose of ivermectin distributed as part of the activities of APOC, and 41 cases of serious adverse reactions (SAEs) were reported, of which 14 were fatal despite appropriate management of the patients. This is an incidence rate even higher than that reported in Léké Division of Cameroon and has led to the establishment of a commission to examine the matter (Dr B. Thylefos, personal communication).

The patho-biological reasons for the occurrence of *Loa*-encephalopathy following treatment with DEC or with ivermectin, mainly seen in patients heavily infected with

*Loa* microfilariae, are not well understood, and co-factors may exist that account for the fact that some patients do not develop SAEs despite having high *Loa* microfilaraemia. Experimental work by Dr Samuel Wanji using an animal model is currently trying to reproduce heavy microfilaraemic infections of human *L. loa* in experimentally infected monkeys (mainly *Mandillus* spp) and to investigate the biochemical and pathological changes that accompany the development of any *Loa*-encephalopathy following ivermectin treatment.

In the original work at the HHRU, Kumba, where it was relatively easy to infect young drills experimentally (either by inoculation of infective larvae or by transplantation of adult worms) with either the nocturnally-periodic simian *Loa* parasite or with the diurnally-periodic human parasite, it was obviously far more difficult to determine whether the nocturnally-periodic simian parasite could be transferred to man. Nevertheless, at that time, before the discovery of the potentially deadly viruses such as Ebola, Marburg and HIV that are believed to originate from monkeys, attempts to infect a human (the author) experimentally with a simian strain of the *Loa* parasite were undertaken. Today, such experiments would not only be viewed as unethical but also as potentially life-threatening.

In 1954 and 1955, the author (who at that time had no signs or symptoms of loiasis and who was not taking any medication, apart from 200 mg proguanil (Paludrine) daily as a prophylactic for malaria), took part in two such experiments, which have not been previously published but are relevant in the light of the localised occurrence of *Loa*-encephalopathy in some individuals following treatment with ivermectin. These attempts at experimental infection of a human being with simian *Loa* are as follows:

In July 1954, a large male drill, which had been shot in the forest near Kumba some 3–4 hours previously, was brought into the laboratory by the Unit's hunter. It was immediately dissected and a total of seven male and fifteen female mature simian *Loa* worms, all alive, undamaged and motile, were collected from the subcutaneous and intermuscular tissues. The worms were placed in sterile normal saline solution, along with a small quantity of merthiolate, in the same manner that had been used previously to transplant adult simian *Loa* worms successfully into other monkeys. Two and a half hours later, 12 of these live, motile, adult female worms and five males were inserted, under local anaesthesia, into the upper, anterior part of the right thigh of the author by the Medical Officer-in-Charge of the Kumba Medical Field Unit. After making a 3-inch, longitudinal incision through the skin and the superficial fascia, the simian *Loa* worms were inserted, some into the sub-cutaneous tissue and others under the

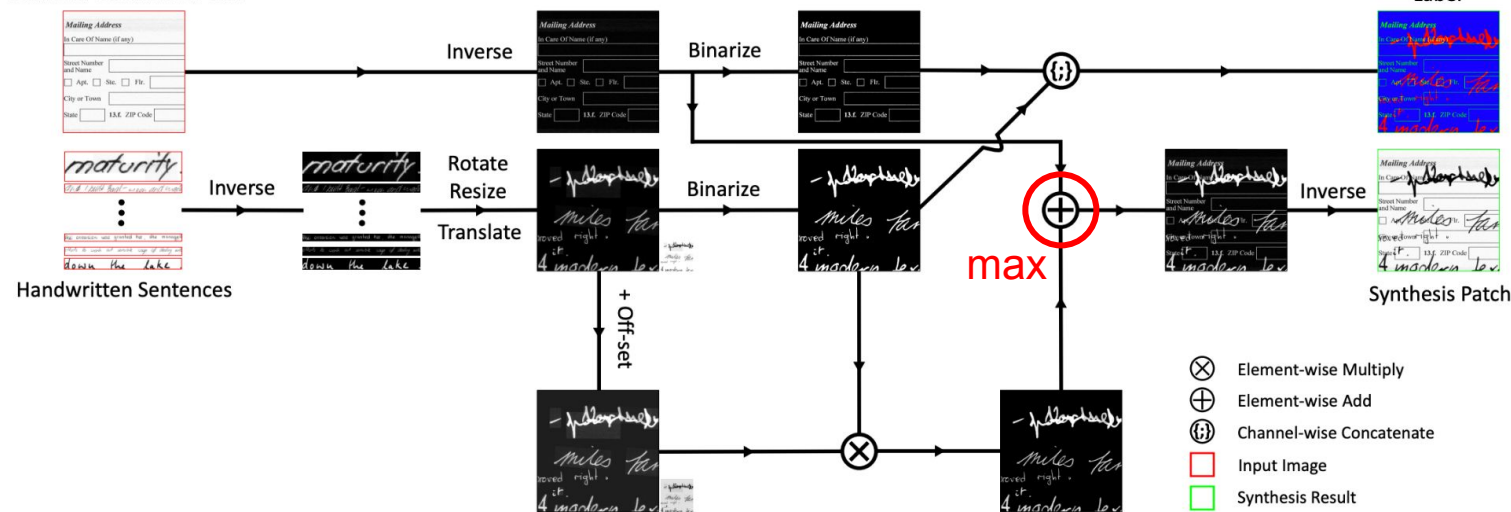
# 3 - Подготовка данных - наложение и маски

## Способы наложения

- alpha-blending
- ИЗ СТАТЬИ
- СВОЙ\*

Handwritten Text Segmentation via End-to-End Learning of Convolutional Neural Networks, 2019 <https://arxiv.org/pdf/1906.05229.pdf>

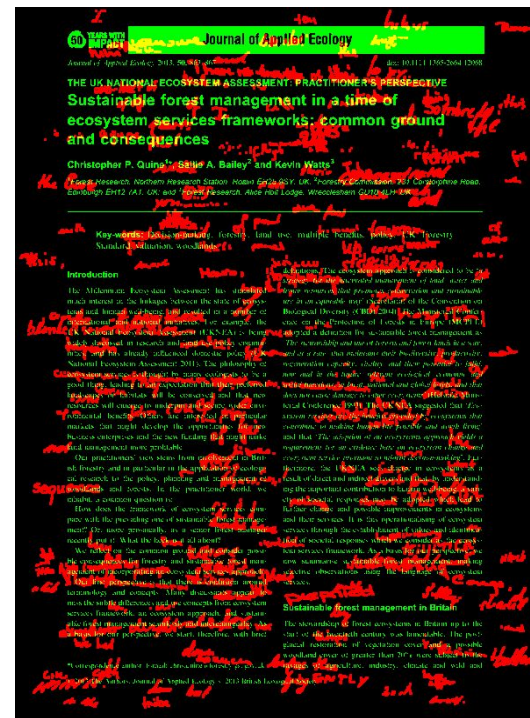
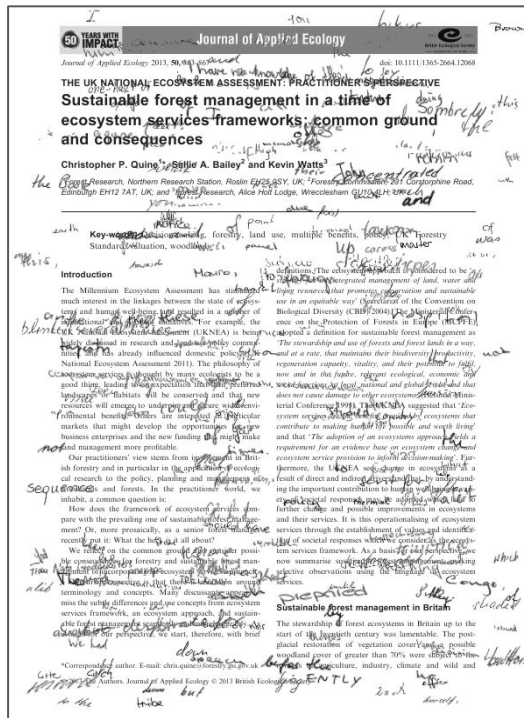
Scanned Document Patch



# 3 - Подготовка данных - Результат

## Результат:

- PubLayNet (10k) + фрагменты (47k) = MixDataset (10k)
- фреймворк для любых входных данных



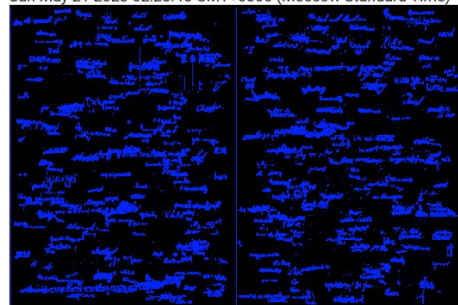


# 4 - Процесс обучения - Подход

- Аугментации
  - случайный поворот
  - случайное отражение по горизонтали и вертикали
- Оптимизируем DiceLoss с помощью Adam
  - Динамически уменьшаем lr на плато
- 2080 ti
- Torch / Pytorch Lightning / Tensorboard

batch\_1/pred/epoch\_0  
tag: batch\_1/pred/epoch\_0  
step 0

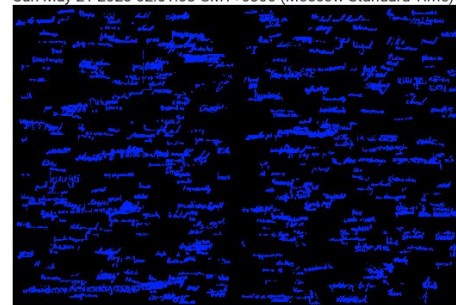
Sun May 21 2023 02:28:45 GMT+0300 (Moscow Standard Time)



lightning\_logs/version\_99

batch\_1/pred/epoch\_1  
tag: batch\_1/pred/epoch\_1  
step 0

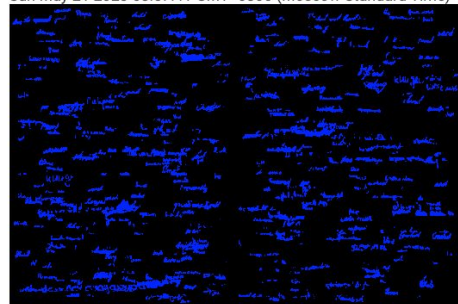
Sun May 21 2023 02:51:03 GMT+0300 (Moscow Standard Time)



lightning\_logs/version\_99

batch\_1/pred/epoch\_4  
tag: batch\_1/pred/epoch\_4  
step 0

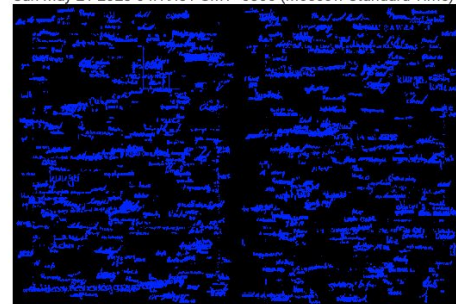
Sun May 21 2023 03:57:41 GMT+0300 (Moscow Standard Time)



lightning\_logs/version\_99

batch\_1/pred/epoch\_5  
tag: batch\_1/pred/epoch\_5  
step 0

Sun May 21 2023 04:19:51 GMT+0300 (Moscow Standard Time)



lightning\_logs/version\_99

## 4 - Процесс обучения - Валидационные метрики

$$\text{Accuracy} = \frac{TP + TN}{TP + TN + FP + FN}$$

$$\text{Precision} = \frac{TP}{TP + FP}$$

$$\text{Recall} = \frac{TP}{TP + FN}$$

$$F1 - score = \frac{2 * Recall * Precision}{Recall + Precision} = \frac{2 * TP}{2 * TP + FP + FN}$$

# 4 - Процесс обучения - Результаты

25 эпох

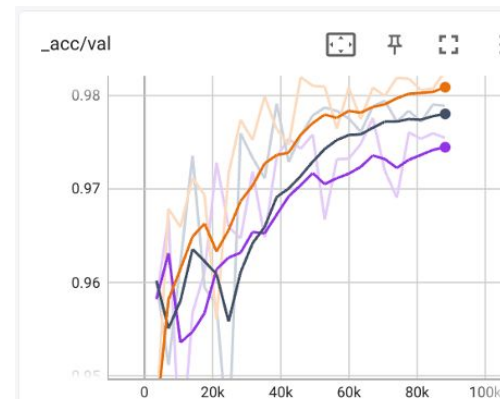
Модель	Кол-во параметров	Accuracy	Precision	Recall	F1-score
Unet 16-32-64-128 (128)	1.9 M	0.976	0.942	0.892	0.916
Unet 32-64-128-256 (124)	7.8 M	0.979	0.949	0.910	0.929
Unet 64-128-256-512 (123)	31.0 M	<b>0.983</b>	<b>0.959</b>	<b>0.924</b>	<b>0.941</b>

$$Accuracy = \frac{TP + TN}{TP + TN + FP + FN}$$

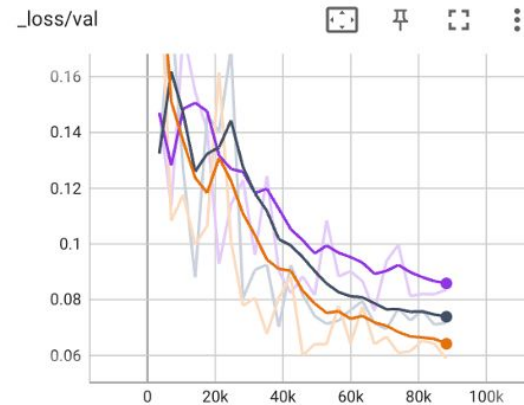
$$Precision = \frac{TP}{TP + FP}$$

$$Recall = \frac{TP}{TP + FN}$$

$$F1 - score = \frac{2 * Recall * Precision}{Recall + Precision} = \frac{2 * TP}{2 * TP + FP + FN}$$



Run	Smoothed Value	Step
lightning_logs/version_123	0.9809	0.9826 88,224
lightning_logs/version_124	0.978	0.9789 88,224
lightning_logs/version_128	0.9745	0.9755 88,224





# 4 - Процесс обучения - Результаты

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Open Access  
Volume 2011, Article ID 125168, 7 pages  
doi:10.5402/2011/125168

Prime scab premiere should, well joint May

Research Article

## Cholesterol, C-Reactive Protein, and Periodontitis: HMG-CoA-Reductase Inhibitors (Statins) as Effect Modifiers

Peter Meisel,<sup>1</sup> Thomas Kohlmann,<sup>2</sup> Henri Wallaschowski,<sup>3</sup> Heyo K. Kroemer,<sup>1</sup> and Thomas Kocher<sup>1</sup>

<sup>1</sup>Department of Pharmacology, University of Greifswald, 17475 Greifswald, Germany  
<sup>2</sup>Department of Community Medicine, University of Greifswald, 17475 Greifswald, Germany  
<sup>3</sup>Department of Clinical Chemistry, University of Greifswald, 17475 Greifswald, Germany

Correspondence should be addressed to Thomas Kohlmann, thomas.kohlmann@uni-greifswald.de

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Common risk factors of periodontitis and cardiovascular diseases fuel the debate on interrelationships between them. We prove whether statins influence periodontal parameters by affecting either of these factors. Out of the 4,290 subjects of SHIP (Study of Health in Pomerania), we included subjects aged 45 years with statins, 2957 without) and excluded edentulous. We determined periodontal measures, cholesterol fractions, and inflammation markers. Statin use and periodontal risk factors were assessed. Gingival plaque and periodontal attachment loss were related with systemic LDL cholesterol ( $P < 0.001$ ) and C-reactive protein (CRP) ( $P = 0.019$ ) revealing interaction with statin use. When adjusted for age, sex, smoking, diabetes, education, and dental service, statins were identified as effect modifiers abolishing the relationship between attachment loss and LDL and between gingival plaque and LDL (interactions  $P < 0.001$ ). No statin-related interaction was observed with increase in CRP. The interaction supports the view of interrelationships between periodontitis and systemic inflammatory mediators.

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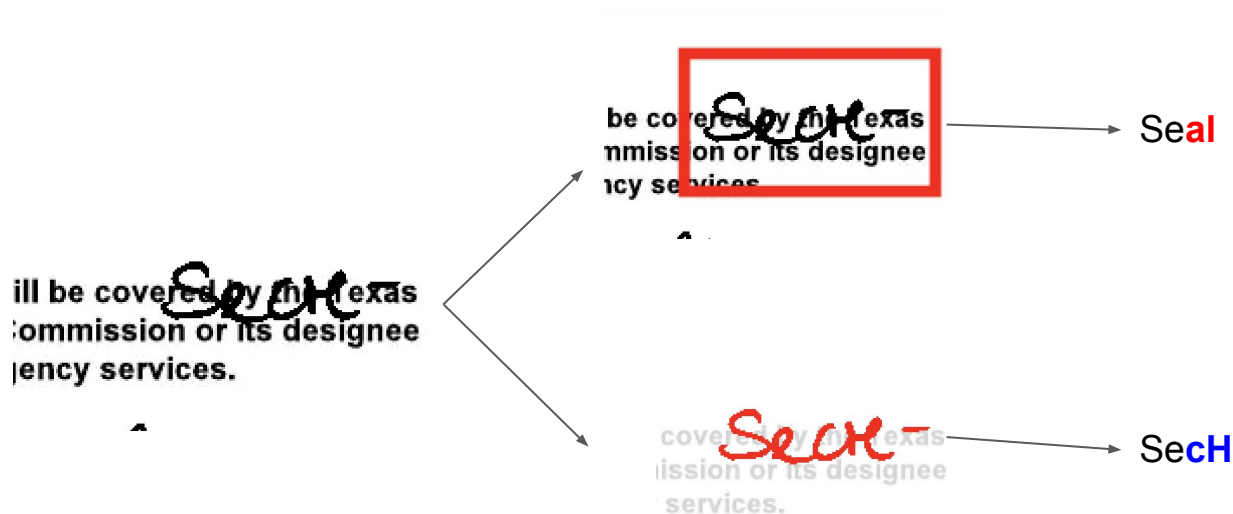
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# 5 - Проверка на реальных данных - Способы

Количественно

Качественно

Handwritten detector + Handwritten reco **VS** Handwritten segmenter + Handwritten reco



# 5 - Проверка на реальных данных - Примеры

Итого: 081446  
23.08.23  
III ррр

Итого: 081446  
23.08.23  
III ррр

Наименование услуги	Платеж	Адрес	Итого	Итого	Итого
красочный	39	112	421	112	421
кажд					

Наименование работ и услуг	Содержание	Содержание	Наименование работ и услуг	Содержание
красочный	38	1234		
кажд	40	567		
гитини		102		

23 445 руб. Иванб Д.С.  
23 445 руб. Геммерб С.С.

Потом он пролетает, красочный, в придои, но в списке рупонасной он черни крас. Обзаведорсе в киоске пресно ввекерантн

Подписи: [подпись] [подпись]

скан

Итого: 081446  
23.08.23  
III ррр

Итого: 081446  
23.08.23  
III ррр

Наименование услуги	Платеж	Адрес	Итого	Итого	Итого
красочный	39	112	421	112	421
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Подписи: [подпись] [подпись]

фото

Итого: 081446  
23.08.23  
III ррр

Итого: 081446  
23.08.23  
III ррр

Наименование услуги	Платеж	Адрес	Итого	Итого	Итого
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Наименование работ и услуг	Содержание	Содержание	Наименование работ и услуг	Содержание
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Подписи: [подпись] [подпись]

фото + фильтр

## 5 - Проверка на реальных данных - Примеры

**ПОЧТА РОССИИ**  **ПОСЫЛКА** Ф. 7-в

**Заполняется отправителем**

От кого Иванов Иван Иванович Кому Семенову Семёну

Откуда 2. Дзержинский Куда Семёнову  
Ильинский пер. 6А,  
кв. 111

Номер мобильного телефона +7 999 888 1166 Индекс отправителя 111

☐ SMS-уведомления ☐ SMS-уведомления

**Заполняется оператором**

11111 2222  
Буквы обязательной ценности (цифры и прописные, 20-2)

3333 4444  
(буквы напечатанного прописки (цифры и прописные, руб. код, Р))

☒ Стандарт ☒ Нестандартная ☒ С описью  
☒ Экспресс ☒ 1 класс ☐ Курьер EMS

Вес 1111

Отслеживание ☐ Отслеживание

*Handwritten notes:*  
- "исправить!" with arrows pointing to the top left and the "1111 2222" box.  
- "неверный" with an arrow pointing to the "1111" weight.  
- "Москва" written above "Семёнову".



[illegible]

## 5 - Проверка на реальных данных - Выводы

- На сканах работает плохо, но на фотографиях удовлетворительно
- Одинаково хорошо распознаются рукописи разной контрастности (синие — менее контрастные, черные — более)
- Если пример похож на обучающие данные, то работает значительно лучше
- Чем меньше в модели параметров, тем лучше она распознает тестовые примеры

## 6 - Заключение - Выводы

1. Был создан фреймворк для создания смешанных (рукописи поверх печатных текстов) наборов данных и сгенерирован датасет с 10 тыс. сэмплами
2. С помощью машинного обучения моделей типа U-net был получен алгоритм, который хорошо показал себя на обучающем датасете
3. Было продемонстрировано реальное применение и сделаны выводы о результатах попытки применения

## 6 - Заключение - Дальнейшее исследование

1. Проверить гипотезы недостаточно хорошей работы модели на реальных данных
  - брать рукописи из сканов
  - расширить за счет аугментаций разнообразие рукописей
  - попробовать другие способы наложения рукописей на печатные страницы
2. Провести качественную оценку на более разнообразных данных
3. Реализовать алгоритм количественной оценки
4. Поэкспериментировать с архитектурой модели
  - глубины сверток в слоях U-Net
  - другие архитектуры