

Klasyfikacja całych słów

Zagdnieniem jakie poruszymy w tym rozdziale jest rozpoznawanie całych słów zapisanych pismem odręcznym.

Rozpoczynam od załadowania niezbędnych bibliotek. Będziemy używać biblioteki “Mxnet” oraz “GluonNLP” do trenowania sieci neuronowej, która posłuży do rozpoznawania pisma odręcznego. Dane testowe pochodzą ze zbioru odręcznie zapisanych formularzy iam.

Do przygotowania zbioru danych użyjemy biblioteki pochodzącej ze zbioru AWS o nazwie OCR. Dzięki tej bibliotece możemy wczytać zbiór i przygotować go do przetwarzania. Ważne jest aby w pliku credentials.json określić dane dostępowe do api serwisu iam.

```
[30]: ### Import bibliotek

import random

random.seed(123)

import matplotlib.pyplot as plt
import matplotlib.patches as patches
import mxnet as mx
import gluonnlp as nlp
import numpy as np
from skimage import transform as skimage_tf, exposure
from tqdm import tqdm

from ocr.utils.expand_bounding_box import expand_bounding_box
from ocr.utils.sclite_helper import ScliteHelper
from ocr.utils.iam_dataset import IAMDataset, resize_image, crop_image,
    ↪crop_handwriting_page
from ocr.utils.word_to_line import sort_bbs_line_by_line, crop_line_images
from ocr.paragraph_segmentation_dcnn import SegmentationNetwork,
    ↪paragraph_segmentation_transform
from ocr.utils.encoder_decoder import Denoiser, ALPHABET, encode_char,
    ↪decode_char, EOS, BOS

from ocr.utils.denoiser_utils import SequenceGenerator

from ocr.utils.beam_search import ctcBeamSearch

from ocr.word_and_line_segmentation import SSD as WordSegmentationNet,
    ↪predict_bounding_boxes
```

```

from ocr.handwriting_line_recognition import Network as _
    ↪ HandwritingRecognitionNet, handwriting_recognition_transform
from ocr.handwriting_line_recognition import decode as decoder_handwriting, _
    ↪ alphabet_encoding

```

```
[2]: ctx = mx.gpu(0)
```

Przygotowanie zbioru danych.

Zbiór pobieramy z serwera iam. Następnie losowo wybieramy 4 formularze do analizy. Poniżej zostały wyświetlone formularze.

```
[3]: test_ds = IAMDataset("form_original", train=False)
```

```
[4]: random.seed(1)
```

```

[5]: figs_to_plot = 4
    images = []

    n = 0
    for i in range(0, figs_to_plot):
        n = int(random.random()*len(test_ds))
        image, _ = test_ds[n]
        images.append(image)

```

```

[6]: fig, axs = plt.subplots(int(len(images)/2), 2, figsize=(15, 10 * len(images)/
    ↪ 2))

    for i, image in enumerate(images):
        y, x = int(i/2), int(i%2)
        axs[y, x].imshow(image, cmap='Greys_r')
        axs[y, x].axis('off')

```

Sentence Database
N01-057

Geoffrey set himself to consider the movements of the Bentley. It had passed him at the temporary bridge over the Tevere at a few minutes past ten on the previous night. He worked out the distance on the presumption that its route had been through Florence and Rome and then across Italy via Foggia to Barietta. It came to just over six hundred miles.

Geoffrey set himself to consider the movements of the Bentley. It had passed him at the temporary bridge over the Tevere at a few minutes past ten on the previous night. He worked out the distance on the presumption that its route had been through Florence and Rome and then across Italy via Foggia to Barietta. It came to just over six hundred miles.

Name:
John

Sentence Database
N04-100

Ever known us bowl a wide about your Service? Check and counter-check - nothing but the truth. Somewhat embarrassing, what?" "How can the truth be embarrassing?" John ripped his double gin with relish. It was his favorite brand, he was, on the verge of a new chapter in his career, and his companion's attitude was challenging.

Ever known us bowl a wide about your Service? Check and counter-check - nothing but the truth. Somewhat embarrassing, what?" "How can the truth be embarrassing?" John ripped his double gin with relish. It was his favorite brand, he was, on the verge of a new chapter in his career, and his companion's attitude was challenging.

Name:

Sentence Database
P03-029

Now Nigel had every right to go where he liked ~~to go where~~ during his off-duty periods when she was not free; this much they had conceded one to the other. They rarely found they were off duty together, and the situation would have been intolerable had there not been given and take about their relationship. So when Nigel had told her about taking Luke's evening surgery she had said,

Now Nigel had every right to go where he liked ~~to go where~~ during his off-duty periods when she was not free; this much they had conceded one to the other. They rarely found they were off duty together, and the situation would have been intolerable had there not been given and take about their relationship. So when Nigel had told her about taking Luke's evening surgery she had said,

Name:

Sentence Database
N02-082

"You talk as though we were alone on Balicon!" She avoided his gaze, and tried to ignore that last impertinent remark. "With four other people." "When you never once managed to circumvent." The mockery in his voice had deepened. "With all due deference, Miss Deane - come off it!" She met his eyes then.

"You talk as though we were alone on Balicon!" She avoided his gaze, and tried to ignore that last impertinent remark. "With four other people." "When you never once managed to circumvent." The mockery in his voice had deepened. "With all due deference, Miss Deane - come off it!" She met his eyes then.

Name:
Howard Heston

Segmentacja akapitów

Mając obraz formularza w zbiorze danych IAM, należy przewidzieć obszar w którym występuje tekst pisany odręcznie. Model został przeszkolony przy użyciu algorytmu omówionego w notatniku segmentacja akapitów.

```
[8]: paragraph_segmentation_net = SegmentationNetwork(ctx=ctx)
paragraph_segmentation_net.cnn.load_parameters("models/paragraph_segmentation2.
↳params", ctx=ctx)
```

```
[9]: paragraph_segmentation_net.hybridize()
```

```
[10]: form_size = (1120, 800)

predicted_bbs = []

fig, axs = plt.subplots(int(len(images)/2), 2, figsize=(15, 9 * len(images)/2))
for i, image in enumerate(images):
    s_y, s_x = int(i/2), int(i%2)
    resized_image = paragraph_segmentation_transform(image, form_size)
    bb_predicted = paragraph_segmentation_net(resized_image.as_in_context(ctx))
    bb_predicted = bb_predicted[0].asnumpy()
    bb_predicted = expand_bounding_box(bb_predicted, expand_bb_scale_x=0.03,
                                     expand_bb_scale_y=0.03)

    predicted_bbs.append(bb_predicted)

    axs[s_y, s_x].imshow(image, cmap='Greys_r')
    axs[s_y, s_x].set_title("{}".format(i))

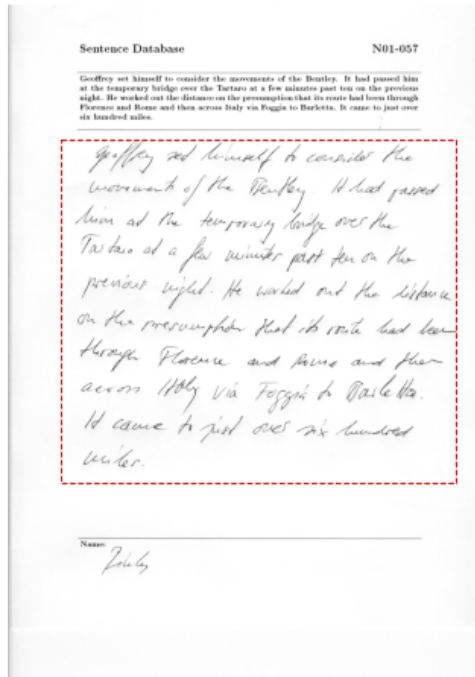
    (x, y, w, h) = bb_predicted
    image_h, image_w = image.shape[-2:]
    (x, y, w, h) = (x * image_w, y * image_h, w * image_w, h * image_h)
    rect = patches.Rectangle((x, y), w, h, fill=False, color="r", ls="--")
    axs[s_y, s_x].add_patch(rect)
    axs[s_y, s_x].axis('off')
```

[05:11:06] ../src/operator/nn/./cudnn/./cudnn_algoreg-inl.h:97: Running
↳performance tests

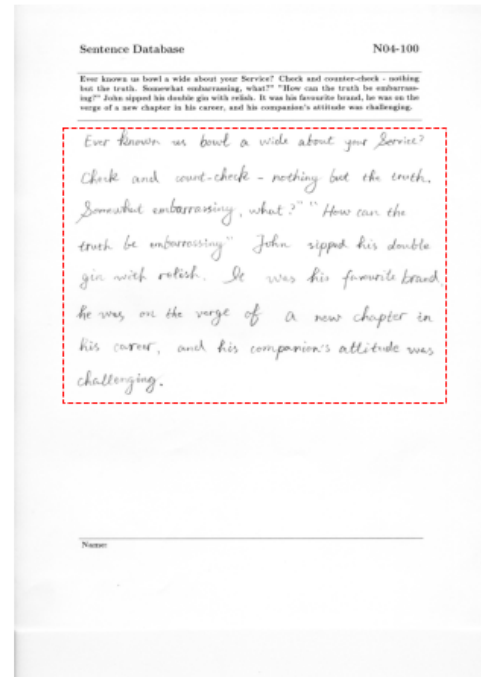
to find the best convolution algorithm, this can take a while... (set the
↳environment

variable MXNET_CUDNN_AUTOTUNE_DEFAULT to 0 to disable)

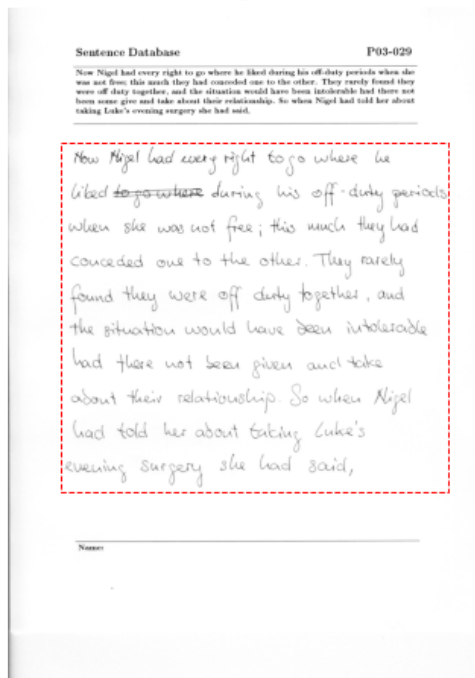
0



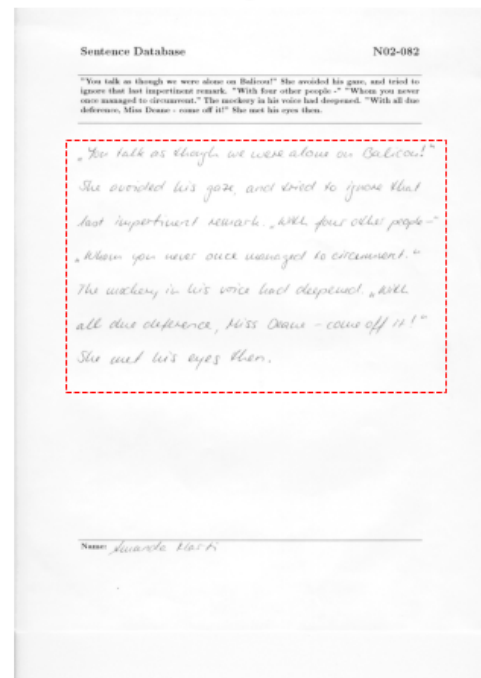
1



2



3



Przygotowanie zdjęć

Wycinamy z obrazu tylko ramkę z ręcznie pisanym tekstem i dostarczamy ją dalej do algorytmu.

```
[11]: segmented_paragraph_size = (700, 700)
fig, axs = plt.subplots(int(len(images)/2), 2, figsize=(15, 9 * len(images)/2))
```

```

paragraph_segmented_images = []

for i, image in enumerate(images):
    s_y, s_x = int(i/2), int(i%2)

    bb = predicted_bbs[i]
    image = crop_handwriting_page(image, bb,
    ↪image_size=segmented_paragraph_size)
    paragraph_segmented_images.append(image)

    axs[s_y, s_x].imshow(image, cmap='Greys_r')
    axs[s_y, s_x].axis('off')

```

Geoffrey set himself to consider the movements of the Bentley. It had passed him at the temporary bridge over the Tevere at a few minutes past ten on the previous night. He worked out the distance on the presumption that its route had been through Florence and Rome and then across Italy via Foggia to Bari. It came to just over six hundred miles.

Ever known us bowl a wide about your Service? Check and count-check - nothing but the truth. Somewhat embarrassing, what?" "How can the truth be embarrassing?" John sipped his double gin with relish. It was his favourite brand, he was, on the verge of a new chapter in his career, and his companion's attitude was challenging.

Now Nigel had every right to go where he liked ~~to go where~~ during his off-duty periods when she was not free; this much they had conceded one to the other. They rarely found they were off duty together, and the situation would have been intolerable had there not been given and take about their relationship. So when Nigel had told her about taking Luke's evening surgery she had said,

"You talk as though we were alone on Balcon!" She avoided his gaze, and tried to ignore that last impertinent remark. "With four other people-" "When you never once managed to circumvent." The wackiness in his voice had deepened. "With all due deference, Miss Deane - come off it!" She met his eyes then.

Segmentacja lini tekstu i słów

Mając formularz zawierający wyłącznie tekst pisany odręcznie, należy przewidzieć ramkę dla każdego słowa. Sposób działania modelu został przedstawiony w notatniku segmentacja tekstu i słów.

```
[12]: word_segmentation_net = WordSegmentationNet(2, ctx=ctx)
word_segmentation_net.load_parameters("models/word_segmentation2.params")
word_segmentation_net.hybridize()
```

```
[13]: min_c = 0.1
overlap_thres = 0.1
topk = 600

fig, axs = plt.subplots(int(len(paragraph_segmented_images)/2), 2,
                        figsize=(15, 5 * int(len(paragraph_segmented_images)/
↪2)))
predicted_words_bbs_array = []

for i, paragraph_segmented_image in enumerate(paragraph_segmented_images):
    s_y, s_x = int(i/2), int(i%2)

    predicted_bb = predict_bounding_boxes(
        word_segmentation_net, paragraph_segmented_image, min_c, ↪
↪overlap_thres, topk, ctx)

    predicted_words_bbs_array.append(predicted_bb)

axs[s_y, s_x].imshow(paragraph_segmented_image, cmap='Greys_r')
for j in range(predicted_bb.shape[0]):
    (x, y, w, h) = predicted_bb[j]
    image_h, image_w = paragraph_segmented_image.shape[-2:]
    (x, y, w, h) = (x * image_w, y * image_h, w * image_w, h * image_h)
    rect = patches.Rectangle((x, y), w, h, fill=False, color="r")
    axs[s_y, s_x].add_patch(rect)
    axs[s_y, s_x].axis('off')
```

Heffer as himself is another the
 instrument of the Bentley it can pass
 him as the temporary bridge over the
 water of the financial part of the
 present light the world and the future
 on the presumption that it will last for
 some time. Florence and Anne were then
 seen by the foggy of the lake
 it came at last and the hundred
 mile.

The house was built about 1700. Some
 Check and over-look - nothing but the truth.
 Somewhat embarrassing, what it does is the
 truth is embarrassing. John says the double
 in with rest. It was the former time
 the was the way of a new chapter in
 the work, with the companion attitude was
 challenging.

New type and every day to go where is
 like to go during an off-duty periods
 when she was not free. The much they had
 conceived was to the state. They rarely
 found they were off duty together. And
 the situation would have been intolerable
 had there not been even one more
 about their relationship. It was like
 was told me about taking a
 evening surgery she was kind.

The first of the day was the first of the day
 the second was the first of the day
 the third was the first of the day
 the fourth was the first of the day
 the fifth was the first of the day
 the sixth was the first of the day
 the seventh was the first of the day
 the eighth was the first of the day
 the ninth was the first of the day
 the tenth was the first of the day

Dopasowanie pojedynczych słów do linii

Następnie musimy z tekstu wydobyć całe lini posiadające tekst odreczny.

```
[14]: line_images_array = []
fig, axs = plt.subplots(int(len(paragraph_segmented_images)/2), 2,
                        figsize=(15, 9 * int(len(paragraph_segmented_images)/
→2)))

for i, paragraph_segmented_image in enumerate(paragraph_segmented_images):
    s_y, s_x = int(i/2), int(i%2)
    axs[s_y, s_x].imshow(paragraph_segmented_image, cmap='Greys_r')
    axs[s_y, s_x].axis('off')
    axs[s_y, s_x].set_title("{}".format(i))

    predicted_bbs = predicted_words_bbs_array[i]
    line_bbs = sort_bbs_line_by_line(predicted_bbs, y_overlap=0.4)
    line_images = crop_line_images(paragraph_segmented_image, line_bbs)
    line_images_array.append(line_images)
```



```

for line_bb in line_bbs:
    (x, y, w, h) = line_bb
    image_h, image_w = paragraph_segmented_image.shape[-2:]
    (x, y, w, h) = (x * image_w, y * image_h, w * image_w, h * image_h)

    rect = patches.Rectangle((x, y), w, h, fill=False, color="r")
    axs[s_y, s_x].add_patch(rect)

```

0

Geoffrey set himself to consider the
 movements of the Bentley. It had passed
 him at the temporary bridge over the
 Tarrant at a few minutes past ten on the
 previous night. He worked out the distance
 on the presumption that its route had been
 through Florence and Rome and then
 across Italy via Foggia to Bari. It
 came to just over six hundred
 miles.

1

Ever known us bowl a wide about your Service?
 Check and count-check - nothing but the truth.
 Somewhat embarrassing, what?" "How can the
 truth be embarrassing?" John sipped his double
 gin with relish. It was his favourite brand,
 he was on the verge of a new chapter in
 his career, and his companion's attitude was
 challenging.

2

Now Nigel had every right to go where he
 liked ~~to go where~~ during his off-duty periods
 when she was not free; this much they had
 conceded one to the other. They rarely
 found they were off duty together, and
 the situation would have been intolerable
 had there not been given and take
 about their relationship. So when Nigel
 had told her about taking Luke's
 evening surgery she had said,

3

"You talk as though we were alone on Balcon!"
 She avoided his gaze, and tried to ignore that
 last impertinent remark. "Well four other people -"
 "When you never once managed to circumvent."
 The warning in his voice had deepened. "Well
 all due deference, Miss Deane - come off it!"
 She met his eyes then.

Rozpoznawanie pisma

Biorąc pod uwagę każdy wiersz tekstu, przewidujemy ciąg tekstu pisanego odręcznie. Działanie tej sieci zostało przedstawione w notatniku rozpoznawanie pisma.

```
[15]: handwriting_line_recognition_net =
    ↳ HandwritingRecognitionNet(rnn_hidden_states=512,
                                rnn_layers=2,
    ↳ ctx=ctx, max_seq_len=160)
    handwriting_line_recognition_net.load_parameters("models/handwriting_line8.
    ↳ params", ctx=ctx)
    handwriting_line_recognition_net.hybridize()
```

```
[16]: line_image_size = (60, 800)
    character_probs = []
    for line_images in line_images_array:
        form_character_prob = []
        for i, line_image in enumerate(line_images):
            line_image = handwriting_recognition_transform(line_image,
    ↳ line_image_size)
            line_character_prob = handwriting_line_recognition_net(line_image.
    ↳ as_in_context(ctx))
            form_character_prob.append(line_character_prob)
        character_probs.append(form_character_prob)
```

Prawdopodobieństwo znaków w tekście

```
[17]: def get_arg_max(prob):
    """
    The greedy algorithm convert the output of the handwriting recognition
    ↳ network
    into strings.
    """
    arg_max = prob.topk(axis=2).asnumpy()
    return decoder_handwriting(arg_max)[0]
```

```
[18]: def get_beam_search(prob, width=5):
    possibilities = ctcBeamSearch(prob.softmax()[0].asnumpy(),
    ↳ alphabet_encoding, None, width)
    return possibilities[0]
```

Odszumianie tekstu wyjściowego

Używamy denoisera seq2seq, aby przetłumaczyć zaszumione wejście na lepsze jakościowo wyjście.

```
[19]: FEATURE_LEN = 150
    denoiser = Denoiser(alphabet_size=len(ALPHABET), max_src_length=FEATURE_LEN,
    ↳ max_tgt_length=FEATURE_LEN, num_heads=16, embed_size=256, num_layers=2)
```

```
denoiser.load_parameters('models/denoiser2.params', ctx=ctx)
```

```
[20]: denoiser.hybridize(static_alloc=True)
```

```
[21]: ctx_nlp = mx.gpu(0)
language_model, vocab = nlp.model.big_rnn_lm_2048_512(dataset_name='gbw',
↳pretrained=True, ctx=ctx_nlp)
moses_tokenizer = nlp.data.SacreMosesTokenizer()
moses_detokenizer = nlp.data.SacreMosesDetokenizer()
```

```
[22]: beam_sampler = nlp.model.BeamSearchSampler(beam_size=20,
                                                decoder=denoiser.decode_logprob,
                                                eos_id=EOS,
                                                scorer=nlp.model.BeamSearchScorer(),
                                                max_length=150)
```

```
[23]: generator = SequenceGenerator(beam_sampler, language_model, vocab, ctx_nlp,
↳moses_tokenizer, moses_detokenizer)
```

```
[24]: def get_denoised(prob, ctc_bs=False):
    if ctc_bs: # Using ctc beam search before denoising yields only limited
↳improvements a is very slow
        text = get_beam_search(prob)
    else:
        text = get_arg_max(prob)
    src_seq, src_valid_length = encode_char(text)
    src_seq = mx.nd.array([src_seq], ctx=ctx)
    src_valid_length = mx.nd.array(src_valid_length, ctx=ctx)
    encoder_outputs, _ = denoiser.encode(src_seq,
↳valid_length=src_valid_length)
    states = denoiser.decoder.init_state_from_encoder(encoder_outputs,
                                                    )
↳encoder_valid_length=src_valid_length)
    inputs = mx.nd.full(shape=(1,), ctx=src_seq.context, dtype=np.float32,
↳val=BOS)
    output = generator.generate_sequences(inputs, states, text)
    return output.strip()
```

```
[25]: sentence = "This sentnce has an error"
src_seq, src_valid_length = encode_char(sentence)
src_seq = mx.nd.array([src_seq], ctx=ctx)
src_valid_length = mx.nd.array(src_valid_length, ctx=ctx)
encoder_outputs, _ = denoiser.encode(src_seq, valid_length=src_valid_length)
```

```

states = denoiser.decoder.init_state_from_encoder(encoder_outputs,
                                                    □
            ↪encoder_valid_length=src_valid_length)
inputs = mx.nd.full(shape=(1,), ctx=src_seq.ctx, dtype=np.float32, val=BOS)
print(sentence)
print("Choice")
print(generator.generate_sequences(inputs, states, sentence))

```

This sentnce has an eror

Choice

T h i s s e n t e n c e

Wyniki jakościowe

- [AM] Arg Max CTC Decoding
- [BS] Beam Search CTC Decoding
- [D] Adding Text Denoiser

```

[26]: for i, form_character_probs in enumerate(character_probs):
        fig, axs = plt.subplots(len(form_character_probs) + 1,
                                figsize=(10, int(1 + 2.3 * □
            ↪len(form_character_probs))))
        for j, line_character_probs in enumerate(form_character_probs):
            decoded_line_am = get_arg_max(line_character_probs)
            print("[AM]", decoded_line_am)
            decoded_line_bs = get_beam_search(line_character_probs)
            decoded_line_denoiser = get_denoised(line_character_probs, □
            ↪ctc_bs=False)
            print("[D ]", decoded_line_denoiser)

            line_image = line_images_array[i][j]
            axs[j].imshow(line_image.squeeze(), cmap='Greys_r')
            axs[j].set_title("[AM]: {} \n [BS]: {} \n [D ]: {} \n \n".
            ↪format(decoded_line_am, decoded_line_bs, decoded_line_denoiser), □
            ↪fontdict={"horizontalalignment": "left", "family": "monospace"}, x=0)
            axs[j].axis('off')
            axs[-1].imshow(np.zeros(shape=line_image_size), cmap='Greys_r')
            axs[-1].axis('off')

```

[AM] Gerfbey sed himself to considedr the

[D] G e o r l y u s e d h i m s e l f

[AM] movement of the Pentey. It had gassed
[D] m o v e m e n t o f t h e e n e m
[AM] bing at tie temroray, budge over the
[D] k i n g a t t h e t e m p o r a
[AM] Tartars ot a few minister past ten on the
[D] Tartars ot a few minister past ten on the
[AM] previous night. He worked out the distance
[D] previous night. He worked out the distance
[AM] on the presumphor that its raite had been
[D] o n t h e p r e s u m p t i o n t h a
[AM] through Florence and some and thar
[D] through Florence and some and thar
[AM] across Itoly via Togggin to Barletta.
[D] a c r o s s I t a l y v i a T o g
[AM] It came 't just over sit hundred
[D] It came 't just over sit hundred
[AM] miler.
[D] miler.
[AM] Ever known us boul a wie about your Bervice?
[D] E v e r k n o w n u s a b o u t a w
[AM] Check and count-checke - nothing but the truth.
[D] C h e c k a n d c o u n t - c h e c k s - n
[AM] Somewhut embarrassiny, what?" "How can the
[D] S o m e w h a t e m b a r r a s s i n g ,
[AM] truch be emburrassiny" John sipped his double
[D] t o u c h b e e m b a r r a s s i n g " J
[AM] gir with rotish. He was his favourite brand,
[D] g i r l w i t h B r o t i s h . H e w
[AM] he was on the verge of a new chapter in
[D] h e w a s o n t h e v e r g e o f a n e w c h a p t e r i n
[AM] his career, and his companion's attitude was
[D] h i s c a r e e r , a n d h i s c o m
[AM] challenging
[D] challenging
[AM] How Migel had every right to go where he
[D] How Migel had every right to go where he
[AM] Liked t during his off-duty gerianls
[D] L i k e d i t d u r i n g h i s
[AM] when she was not free; this much they had
[D] w h e n s h e w a s n o t f r e e ; t h i s m u c h t h e y h a d

[AM] conceded one to the other. They rarely
[D] conceded one to the other. They rarely
[AM] found they were off duty together, and
[D] found they were off duty together, and
[AM] the situation would have been intolerable
[D] the situation would have
[AM] had there not been given and take
[D] had there not been given and take
[AM] about their relationship. So when Miguel
[D] about their relations
[AM] had told her about taking Luttre's
[D] had told her about
[AM] evening surgery she had said,
[D] evening surgery she had said,
[AM] "You talk as though we were alone on Balcony!"
[D] " You talk as though we were
[AM] She avoided his gaze, and tried to ignore that
[D] She avoided his gaze, and
[AM] last impertinent remark. "With four other people-"
[D] last impertinent remark. "
[AM] "Whom you never once managed to circumvent."
[D] " Whom you never once managed
[AM] The mockery, in his voice had deepened. "with
[D] The mockery, in his voice
[AM] all due deference, Miss Deane-leave off it!"
[D] all the deference, Miss
[AM] She met his eyes then.
[D] She met his eyes then.

[AM]: Gerfbey sed himself to considedr the
[BS]: Gerfbey sed himself to consider the
[D]: Georly used himself

Geoffrey sed himself to consider the
[AM]: movement of the Pentey. It had gassed
[BS]: movement of the Pentey. It had gassed
[D]: movement of the enem

movement of the Pentey. It had gassed
[AM]: bing at tie temroray, budge over the
[BS]: bing at tie temroray, budge over the
[D]: king at the tempora

him at the temporary bridge over the
[AM]: Tartars of a few minister past ten on the
[BS]: Tartars of a few minister past ten on the
[D]: Tartars of a few minister past ten on the

Tartars of a few minister past ten on the
[AM]: previous night. He worked out the distance
[BS]: previous night. He worked out the distance
[D]: previous night. He worked out the distance

previous night. He worked out the distance
[AM]: on the presumphor that its raite had been
[BS]: on the presumphor that its raite had been
[D]: on the presumption tha

on the presumphor that its raite had been
[AM]: through Florence and some and thar
[BS]: through Florence and some and thar
[D]: through Florence and some and thar

through Florence and some and thar
[AM]: across Itoly via Togggin to Barletta.
[BS]: across Itoly via Togggin to Barletta.
[D]: across Italy via Tog

across Itoly via Togggin to Barletta.
[AM]: It came 't just over sit hundred
[BS]: It came 't just over sit hundred
[D]: It came 't just over sit hundred

It came 't just over sit hundred
[AM]: miler
[BS]: miler
[D]: miler.

miler.



[AM]: Ever known us bowl a wide about your Service?
[BS]: Ever known us bowl a wide about your Service?
[D]: E v e r k n o w n u s a b o u t a w

Ever known us bowl a wide about your Service?

[AM]: Check and count-checke - nothing but the truth.
[BS]: Check and count-checke - nothing but the truth.
[D]: C h e c k a n d c o u n t - c h e c k s - n

Check and count-check - nothing but the truth.

[AM]: Somewhut embarrassy, what?" "How can the
[BS]: Somewhut embarrassy, what?" "How can the
[D]: S o m e w h a t e m b a r r a s s i n g ,

Somewhat embarrassing, what?" "How can the

[AM]: truch be emburrassiny" John sipped his double
[BS]: truch be emburrassiny" John sipped his double
[D]: t o u c h b e e m b a r r a s s i n g " J

truth be embarrassing" John sipped his double

[AM]: gir with rotish. He was his favourite brand,
[BS]: gir with rotish. He was his favourite brand,
[D]: g i r l w i t h B r o t i s h . H e w

gin with relish. It was his favourite brand,

[AM]: he was on the verge of a new chapter in
[BS]: he was on the verge of a new chapter in
[D]: h e w a s o n t h e v e r g e o f a n e w c h a p t e r i n

he was on the verge of a new chapter in

[AM]: his career, and his companion's attitude was
[BS]: his career, and his companion's attitude was
[D]: h i s c a r e e r , a n d h i s c o m

his career, and his companion's attitude was
[AM]: challenging
[BS]: challenging
[D]: challenging

challenging



[AM]: How Migel had every right to go where he
[BS]: How Migel had every right to go where he
[D]: How Migel had every right to go where he

How Migel had every right to go where he

[AM]: Liked t during his off-duty gerianls
[BS]: Liked t during his off-duty gerianls
[D]: L i k e d i t d u r i n g h i s

liked ~~to go where~~ during his off-duty periods

[AM]: when she was not free; this much they had
[BS]: when she was not free; this much they had
[D]: when she was not free; this much they had

when she was not free; this much they had

[AM]: conceded one to the other. They rarely
[BS]: conceded one to the other. They rarely
[D]: conceded one to the other. They rarely

conceded one to the other. They rarely

[AM]: found they were off duty together, and
[BS]: found they were off duty together, and
[D]: found they were off duty together, and

found they were off duty together, and

[AM]: the situation would have been intolerable
[BS]: the situation would have been intolerable
[D]: t h e s i t u a t i o n w o u l d h a

the situation would have been intolerable

[AM]: had there not been given and take
[BS]: had there not been given and take
[D]: had there not been given and take

had there not been given and take

[AM]: about their relationship. So when Migel
[BS]: about their relationship. So when Migel
[D]: a b o u t t h e i r r e l a t i o n s

about their relationship. So when Migel

[AM]: had told her about taking Lutre's
[BS]: had told her about taking Lutre's
[D]: h a d t o l d h e r a b o u t

had told her about taking Luke's

[AM]: evening surgery she had said,
[BS]: evening surgery she had said,
[D]: evening surgery she had said,

evening surgery she had said,



[AM]: "You talk as though we were alone on Balicon!."
[BS]: "You talk as though we were alone on Balicon."
[D]: " Y o u t a l k a s t h o u g h w e w e

"You talk as though we were alone on Balicon!"

[AM]: She avoided his gaze, and tried to ignore that
[BS]: She avoided his gaze, and tried to ignore that
[D]: S h e a v o i d e d h i s g a z e , a n

She avoided his gaze, and tried to ignore that

[AM]: last impertinent remark."With four other people-"
[BS]: last impertinent remark."With four other people-"
[D]: l a s t i m p e r t i n e n t r e m a r k . "

last impertinent remark. "With four other people-"

[AM]: "Whom you never ouce managed to circumient."
[BS]: "Whom you never ouce managed to circumient."
[D]: " W h o m y o u n e v e r o n c e m a

"Whom you never ouce managed to circumient."

[AM]: The mackery, in his voice had deepened. "with
[BS]: The mackery, in his voice had deepened. "with
[D]: T h e m o c k e r y , i n h i s v o i c

The mackery, in his voice had deepened. "With

[AM]: all due deference, Miss Deaue-come off it!"
[BS]: all due deference, Miss Deaue-come off it!"
[D]: a l l t h e d e f e r e n c e , M i s s

all due deference, Miss Deaue - come off it!"

[AM]: She met his eyes then.
[BS]: She met his eyes then.
[D]: S h e m e t h i s e y e s t h e n .

She met his eyes then.



Wyniki ilościowe

Iterujemy przez zbiór testowy, aby otrzymać wskaźnik błędu znaku (ang. Character Error Rate, CER).

```
[27]: sclite = ScliteHelper('../SCTK/bin')

def get_qualitative_results_lines(denoise_func):
    sclite.clear()
    test_ds_line = IAMDataset("line", train=False)
    for i in tqdm(range(1, len(test_ds_line))):
        image, text = test_ds_line[i]
        line_image = exposure.adjust_gamma(image, 1)
        line_image = handwriting_recognition_transform(line_image,
↪line_image_size)
        character_probabilities = handwriting_line_recognition_net(line_image.
↪as_in_context(ctx))
        decoded_text = denoise_func(character_probabilities)
        actual_text = text[0].replace("&quot;", "'').replace("&apos;", "'').
↪replace("&amp;", "&")
        sclite.add_text([decoded_text], [actual_text])

    cer, er = sclite.get_cer()
    print("Mean CER = {}".format(cer))
    return cer

[28]: def get_qualitative_results(denoise_func):
    sclite.clear()
    for i in tqdm(range(1, len(test_ds))):
        image, text = test_ds[i]
        resized_image = paragraph_segmentation_transform(image,
↪image_size=form_size)
        paragraph_bb = paragraph_segmentation_net(resized_image.
↪as_in_context(ctx))
        paragraph_bb = paragraph_bb[0].asnumpy()
        paragraph_bb = expand_bounding_box(paragraph_bb, expand_bb_scale_x=0.
↪01,
                                                expand_bb_scale_y=0.01)
        paragraph_segmented_image = crop_handwriting_page(image, paragraph_bb,
↪image_size=segmented_paragraph_size)
```

```

word_bb = predict_bounding_boxes(word_segmentation_net,
↪paragraph_segmented_image, min_c, overlap_thres, topk, ctx)
line_bbs = sort_bbs_line_by_line(word_bb, y_overlap=0.4)
line_images = crop_line_images(paragraph_segmented_image, line_bbs)

predicted_text = []
for line_image in line_images:
    line_image = exposure.adjust_gamma(line_image, 1)
    line_image = handwriting_recognition_transform(line_image,
↪line_image_size)
    character_probabilities =
↪handwriting_line_recognition_net(line_image.as_in_context(ctx))
    decoded_text = denoise_func(character_probabilities)
    predicted_text.append(decoded_text)

actual_text = text[0].replace("&quot;", "'').replace("&apos;", "'").
↪replace("&amp;", "&")
actual_text = actual_text.split("\n")
if len(predicted_text) > len(actual_text):
    predicted_text = predicted_text[:len(actual_text)]
sclite.add_text(predicted_text, actual_text)

cer, _ = sclite.get_cer()
print("Mean CER = {}".format(cer))
return cer

```

CER z liniami wstępnie segmentowanymi

[32]: get_qualitative_results_lines(get_arg_max)

100%| | 1859/1859 [01:23<00:00, 22.29it/s]

Mean CER = 8.4

[32]: 8.4

[33]: get_qualitative_results_lines(get_denoised)

100%| | 1859/1859 [13:04<00:00, 2.37it/s]

Mean CER = 38.3

[33]: 38.3

```
[34]: get_qualitative_results(get_arg_max)
```

100%| | 231/231 [01:30<00:00, 2.54it/s]

Warning: The comment designation is now **, the line below
has only one comment info character, this may be an error
*?2s as 'Seaweed', and a youngish, sharp-eyed(sp125_8)

Mean CER = 11.6

[34]: 11.6

```
[35]: get_qualitative_results(get_beam_search)
```

100%| | 231/231 [14:46<00:00, 3.84s/it]

Warning: The comment designation is now **, the line below
has only one comment info character, this may be an error
*?2s as 'Seaweed', and a youngish, sharp-eyed(sp125_8)

Mean CER = 11.5

[35]: 11.5

```
[37]: get_qualitative_results(get_denoised)
```

100%| | 231/231 [13:18<00:00, 3.46s/it]

Warning: The comment designation is now **, the line below
has only one comment info character, this may be an error
*?2s as 'Seaweed', and a youngish, sharp-eyed(sp125_8)

Mean CER = 42.7

[37]: 42.7