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Identification of erosion rills via machine learning

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Motivation

- The laborious and slow process of manual digitization of rills
- Existing large database of erosion damage
- Software and computing capacity is available

Goals

- To create a methodology for Assembly and calibrating of the model
- Minimum requirements for time and performance of the operator

High resolution photogrammetry

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- High-resolution soil surface images created using the Structure from Motion photogrammetric method
- Complete with multi-view stereo (MVS)This method is chosen because of the balance between data quality, data acquisition speed and equipment costs
- The photo scan contains many shots of the surface at different angles and several vertical stereo photos
- The distance between the camera and the sample is several tenths of centimeters
- Experimental vessel equipped with reference points and LED lighting
- The photos are merged to create a dense cloud of dots containing up to millions of dots from a cloud of points directly in the software interpolated digital elevation models (DEM) and orthophoto of the surface

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Technology

- Hand digitizing of rills on orthophoto scene
- Creation of multiband composite
- Creation of composite mosaic and its export
- Modification of training data
- Model training
- Using a trained model
- Import of results back into GIS

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Creation of mosaics from a multiband raster and their export

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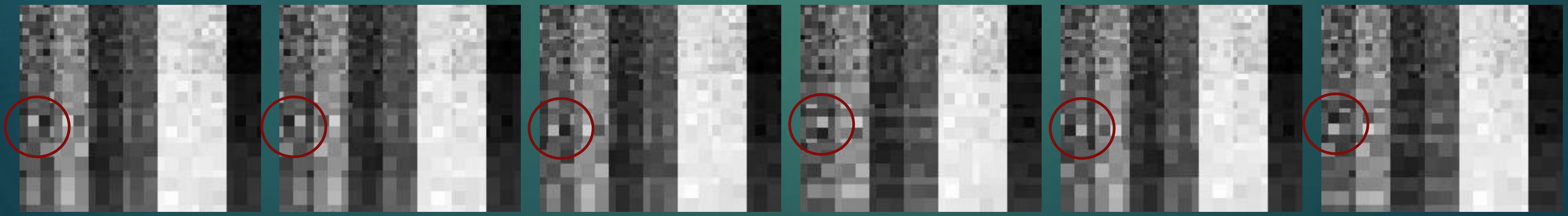
Mosaics

- Variable size of classification window
- R, G, B bands
- Grayscale, Canny Edge
- Grayscale = (0,3 * Red) + (0,59 * Green) + (0,11 * Blue) – linear approximation
- Standardization [0, 1]
- Export as jpg format

Modification of training data

- Only for rill data
- Horizontal and vertical flip
- 90°, 180°, 270° turn
- In order to increase the number of training data



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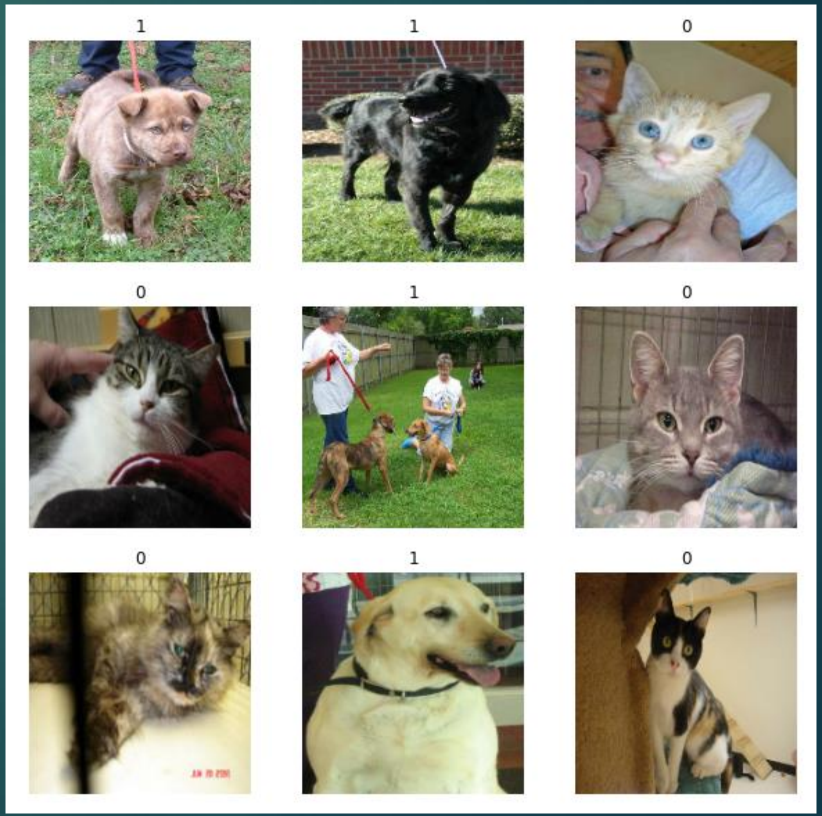
Model

- Python, Tensorflow, Keras
- Deep learning API
- Flexible, Easy, Efective
- Used by NASA, YouTube, Waymo (Chollet 2021)

- Kaggle Cats vs Dogs used as a foundation
- 23 410 training pictures of cats and dogs
- Binary classification



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Model

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```python
#-------------------------------------------------------------------------------
# Name:        module1
# Purpose:
#
# Author:      Adam Tejkl
#
# Created:     05.08.2021
# Copyright:   (c) Adam Tejkl 2021
# Licence:     <your licence>
#-------------------------------------------------------------------------------
import tensorflow as tf
from tensorflow import keras
from tensorflow.keras import layers

import os

print("Import of libraries done")

#%%
adress = "S:/Private/_PROJEKTY/2020_TACR_DPZ/mapa_udalosti/Tejkl_reseni/mosaics"

num_skipped = 0
for folder_name in ("NoRill", "Rill"):
    folder_path = os.path.join(adress, folder_name)
    for fname in os.listdir(folder_path):
        fpath = os.path.join(folder_path, fname)
        try:
            fobj = open(fpath, "rb")
            is_jfif = tf.compat.as_bytes("JFIF") in fobj.peek(10)
        finally:
            fobj.close()

        if not is_jfif:
            num_skipped += 1
            # Delete corrupted image
            os.remove(fpath)

print("Deleted %d images" % num_skipped)

#%%

image_size = (33, 132)
batch_size = 32

train_ds = tf.keras.preprocessing.image_dataset_from_directory(
    adress,
    validation_split=0.2,
    subset="training",
    seed=1337,
    image_size=image_size,
    batch_size=batch_size,
)

val_ds = tf.keras.preprocessing.image_dataset_from_directory(
    adress,
    validation_split=0.2,
    subset="validation",
    seed=1337,
    image_size=image_size,
    batch_size=batch_size,
)

print("Training and validation done")

#%%
```

```python
#%%

import matplotlib.pyplot as plt

plt.figure(figsize=(10, 10))
for images, labels in train_ds.take(1):
    for i in range(9):
        ax = plt.subplot(3, 3, i + 1)
        plt.imshow(images[i].numpy().astype("uint8"))
        plt.title(int(labels[i]))
        plt.axis("off")

print("Plotting done")

#%%

##data_augmentation = keras.Sequential(
##    [
##        layers.experimental.preprocessing.RandomFlip("horizontal"),
##        layers.experimental.preprocessing.RandomRotation(0.1),
##    ]
##)

#%%

def make_model(input_shape, num_classes):
    inputs = keras.Input(shape=input_shape)
    # Image augmentation block

##    data_augmentation = keras.Sequential(
##    [
##        layers.experimental.preprocessing.RandomFlip("horizontal"),
##        layers.experimental.preprocessing.RandomRotation(0.1),
##    ]
##    )

##    x = data_augmentation(inputs)
    x = inputs

    # Entry block
    x = layers.experimental.preprocessing.Rescaling(1.0 / 255)(x)
    x = layers.Conv2D(32, 3, strides=2, padding="same")(x)
    x = layers.BatchNormalization()(x)
    x = layers.Activation("relu")(x)

    x = layers.Conv2D(64, 3, padding="same")(x)
    x = layers.BatchNormalization()(x)
    x = layers.Activation("relu")(x)

    previous_block_activation = x  # Set aside residual

    for size in [128, 256, 512, 728]:
        x = layers.Activation("relu")(x)
        x = layers.SeparableConv2D(size, 3, padding="same")(x)
        x = layers.BatchNormalization()(x)

        x = layers.Activation("relu")(x)
        x = layers.SeparableConv2D(size, 3, padding="same")(x)
        x = layers.BatchNormalization()(x)

        x = layers.MaxPooling2D(3, strides=2, padding="same")(x)

        # Project residual
        residual = layers.Conv2D(size, 1, strides=2, padding="same")(
```

```python
    previous_block_activation = x  # Set aside residual

    for size in [128, 256, 512, 728]:
        x = layers.Activation("relu")(x)
        x = layers.SeparableConv2D(size, 3, padding="same")(x)
        x = layers.BatchNormalization()(x)

        x = layers.Activation("relu")(x)
        x = layers.SeparableConv2D(size, 3, padding="same")(x)
        x = layers.BatchNormalization()(x)

        x = layers.MaxPooling2D(3, strides=2, padding="same")(x)

        # Project residual
        residual = layers.Conv2D(size, 1, strides=2, padding="same")(
            previous_block_activation
        )
        x = layers.add([x, residual])  # Add back residual
        previous_block_activation = x  # Set aside next residual

    x = layers.SeparableConv2D(1024, 3, padding="same")(x)
    x = layers.BatchNormalization()(x)
    x = layers.Activation("relu")(x)

    x = layers.GlobalAveragePooling2D()(x)
    if num_classes == 2:
        activation = "sigmoid"
        units = 1
    else:
        activation = "softmax"
        units = num_classes

    x = layers.Dropout(0.5)(x)
    outputs = layers.Dense(units, activation=activation)(x)
    return keras.Model(inputs, outputs)

##image_size = (180, 180)

topgis_model = make_model(input_shape=image_size + (3,), num_classes=2)
##keras.utils.plot_model(topgis_model, show_shapes=True)

epochs = 20

callbacks = [keras.callbacks.ModelCheckpoint("save_at_{epoch}.h5"),]

topgis_model.compile(optimizer=keras.optimizers.Adam(1e-3), loss="binary_crossentropy", metrics=["accuracy"],)

topgis_model.fit( train_ds, epochs=epochs, callbacks=callbacks, validation_data=val_ds,)

topgis_model.save("S:/Private/_PROJEKTY/2020_TACR_DPZ/mapa_udalosti/Tejkl_reseni/topgis_model_2")

def analyse_mosaic(mosaic, image_size, input_model):
    img = keras.preprocessing.image.load_img(mosaic, target_size=image_size)
    img_array = keras.preprocessing.image.img_to_array(img)
    img_array = tf.expand_dims(img_array, 0)  # Create batch axis
    predictions = input_model.predict(img_array)
    score = predictions[0]
    print(    "This image is %.2f percent NoRill and %.2f percent Rill."    % (100 * (1 - score), 100 * score))
```

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Testing on the data

- Laboratory rainfall simulator
- Experimental throughs in Jirkov
- Long term erosion research

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Mosaic model for classification

- RGB orthophotos of surface
- Manually digitalized rills
- Category sheet erosion added
- In total 32 orthophotos of surface used
- Mosaics R, G, B, Grayscale, Canny edge 1, Canny edge 2, Canny edge 3

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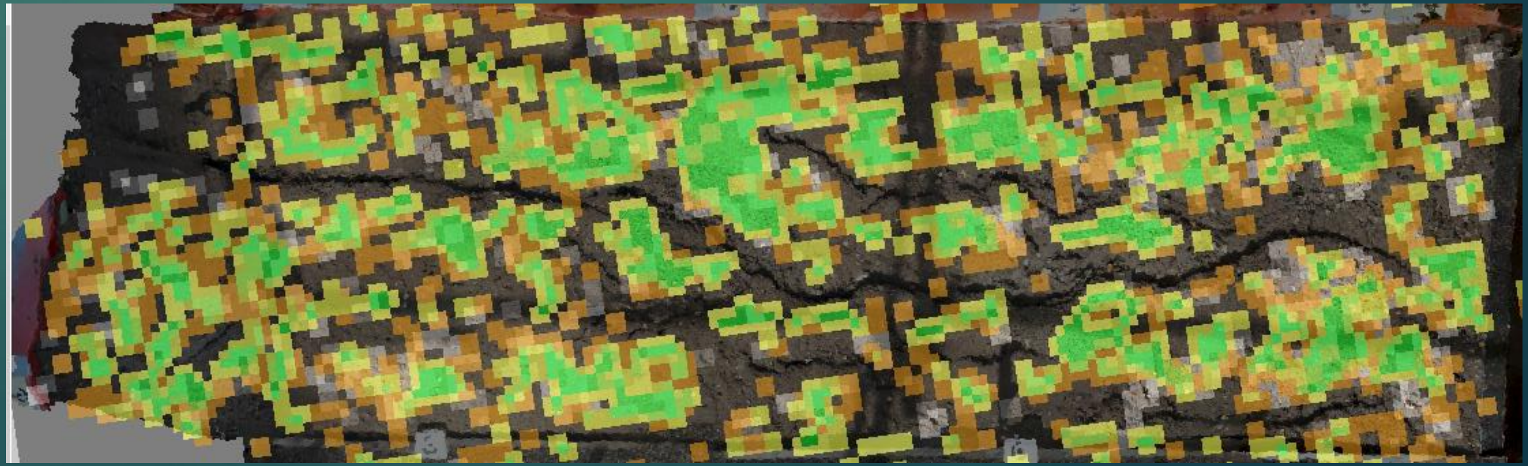
Adding of sheet erosion category

- 27 844 mosaics of no erosion class
- 168 570 mosaics of rill erosion class
- 15 188 mosaics of sheet erosion class
- Validated on 14 orthophotos



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Testing and tuning of superparameters

- The size of the classification window is a key parameter
- Minimum window size - maximum classification accuracy
- Gradual testing of window sizes and statistical evaluation of these tests
- Another parameter of the model is the spatial resolution of the orthophoto image
- Comparison of the pixel edge length of the image and individual surface elements
- Monitoring the relationship between image resolution and the size of the classification window

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Future work

- Methodology for success measurement
- Testing and tuning of superparameters
- Searching for the minimal number of training data
- Statistical analysis of results

Funding

- Technological Agency of the Czech Republic (research project TH02030428)
- Internal student CTU grant (SGS17/173/OHK1)

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Thank you for your attention

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