Digitizing archive atmospheric electric potential gradient data for scientific research

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Introduction

- The **atmospheric electric potential gradient (PG)** has been measured in the **Széchenyi István Geophysical Observatory** in Nagycenk (NCK; near Sopron, Hungary) for more than six decades, since 1961.
- **Problem**: measurements were **recorded on photographic paper** because digital data acquisition was introduced late (in 2011). Digital PG data are **only available in the format of hourly averages**.

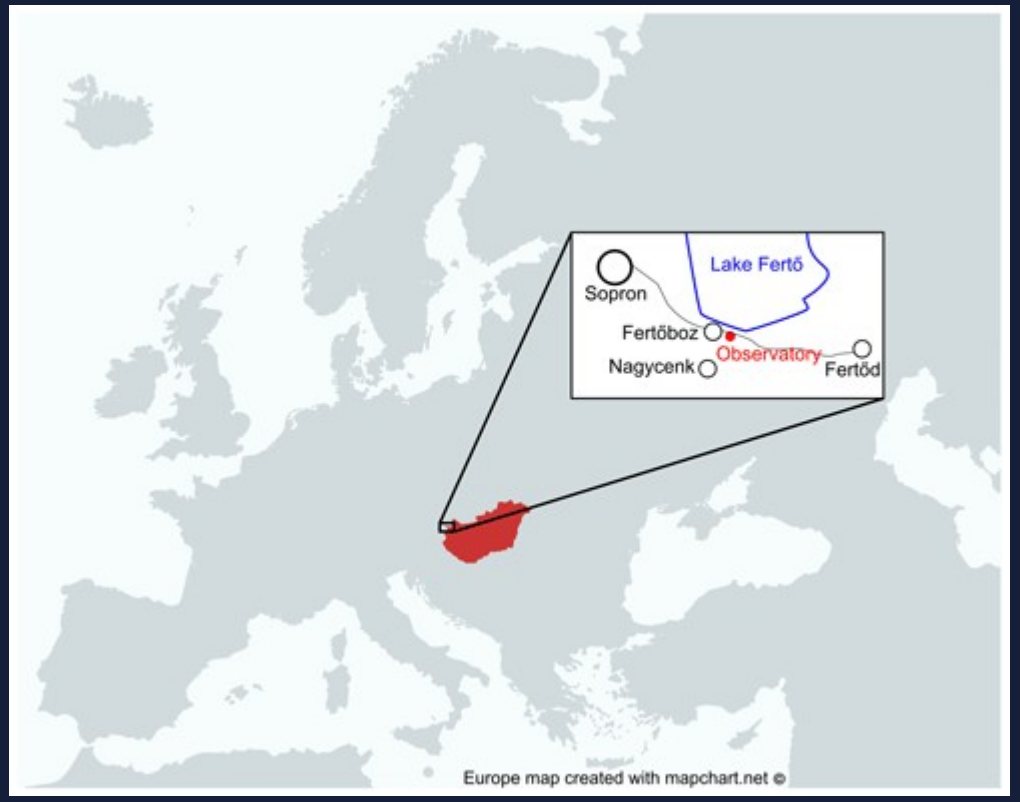


Figure source: Bór et al., Measurements of atmospheric electricity in the Széchenyi István Geophysical Observatory, Hungary. Hist. Geo Space. Sci., 11, 53–70, 2020.

https://doi.org/10.5194/hgss-11-53-2020

Objective of the project

- To **obtain a high time-resolution PG dataset** from the analogue photographical records.

Implementation:

- Creation of an **image processing algorithm**.
- **Scanning** the photo paper rolls of the PG measurement (Figure 1.)
- **Determination of numerical values** (Figure 2.)
  - The value of PG at a given time [V/m].
- **Digitization of a longer period (1999-2009).**

Figure 1.

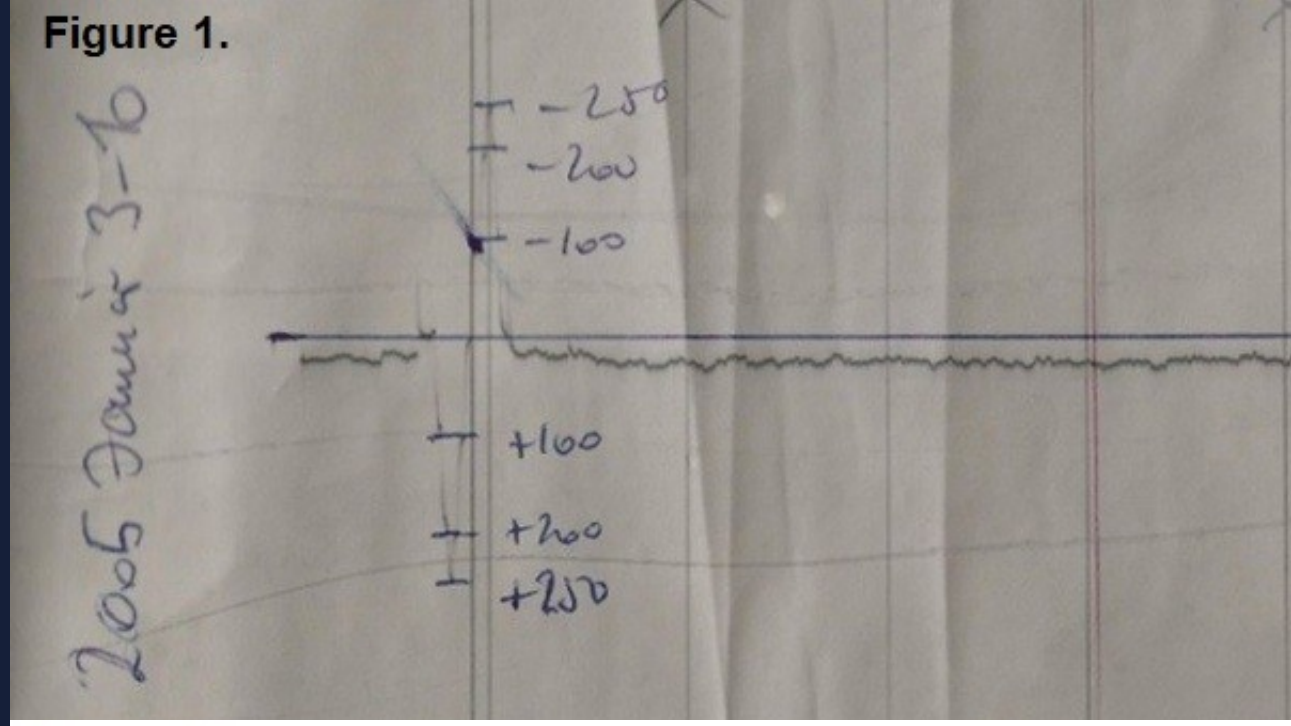


Figure 2.

Date [UTC]	PG [V/m]
2005-01-06 01:59:32;	40.37
2005-01-06 02:00:15;	38.12
2005-01-06 02:00:57;	35.88
2005-01-06 02:01:40;	33.64
2005-01-06 02:02:23;	31.4
2005-01-06 02:03:05;	29.15
2005-01-06 02:03:48;	24.67
2005-01-06 02:04:31;	22.43
2005-01-06 02:05:13;	20.18
2005-01-06 02:05:56;	17.94
2005-01-06 02:06:39;	20.18
2005-01-06 02:07:21;	17.94
2005-01-06 02:08:04;	20.18
2005-01-06 02:08:47;	22.43

Digitization of PG measurements

- **Semi-automatic** approach: automatic digitization but the validation of the result and finding the optimal parameters for the digitization requires supervision from a user.
- **Edge detection** (Figure 3.)
  - Edge: sudden intensity change -> interface between object and background,
  - Detect reference axes and the graph of PG measurement,
  - Canny edge detection algorithm.
- Software implementation
  - Python programming language,
  - OpenCV, NumPy, SciPy, imageio libraries.

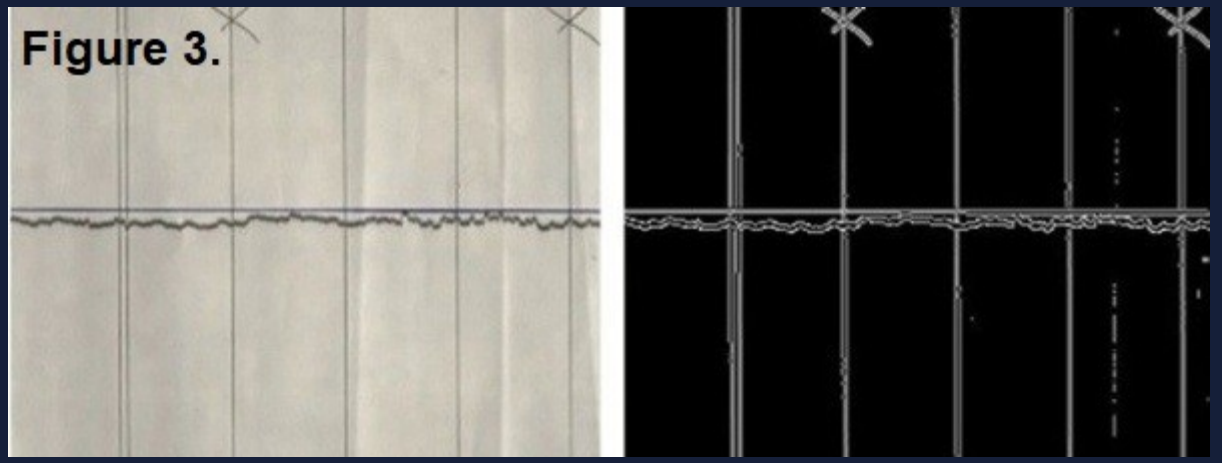
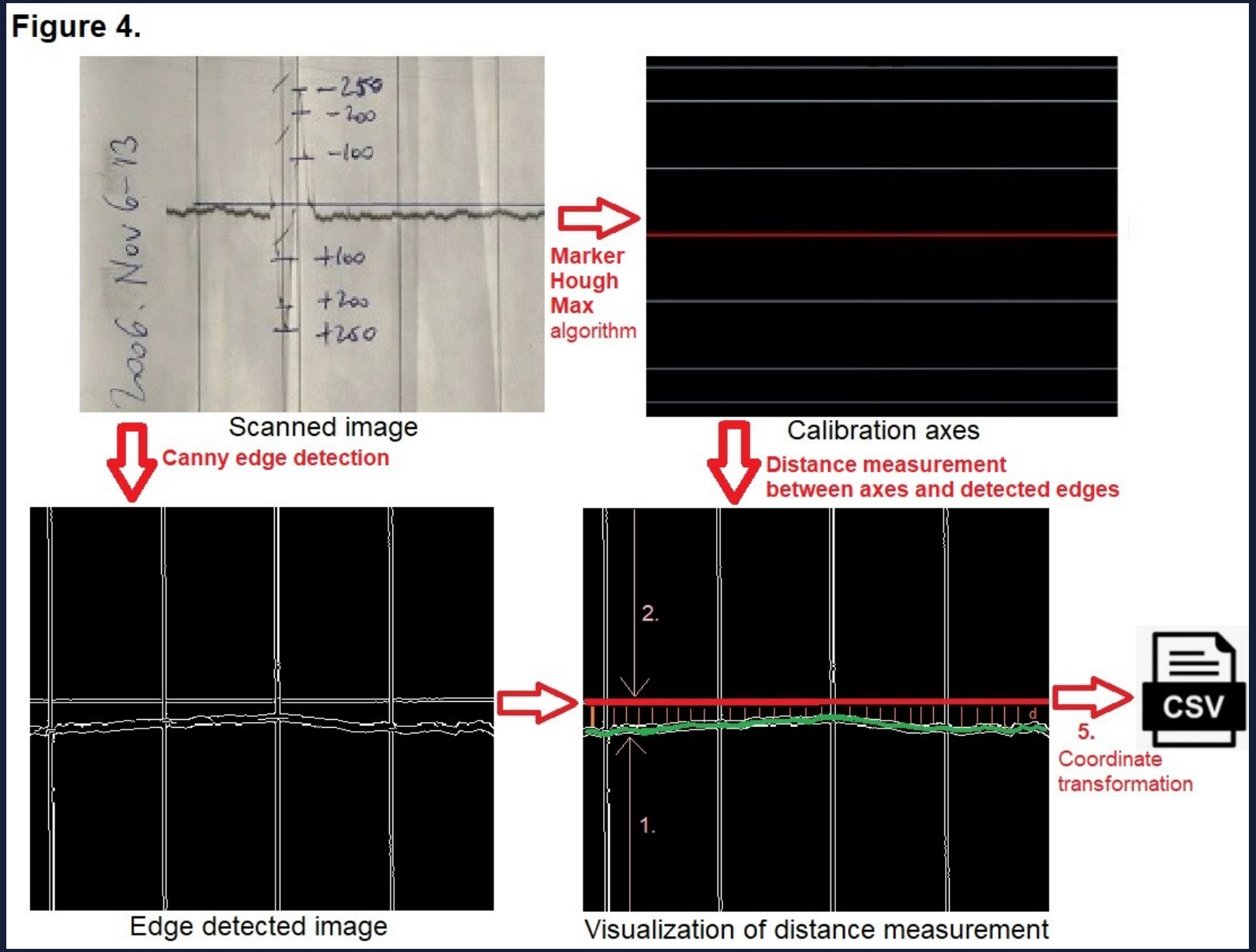
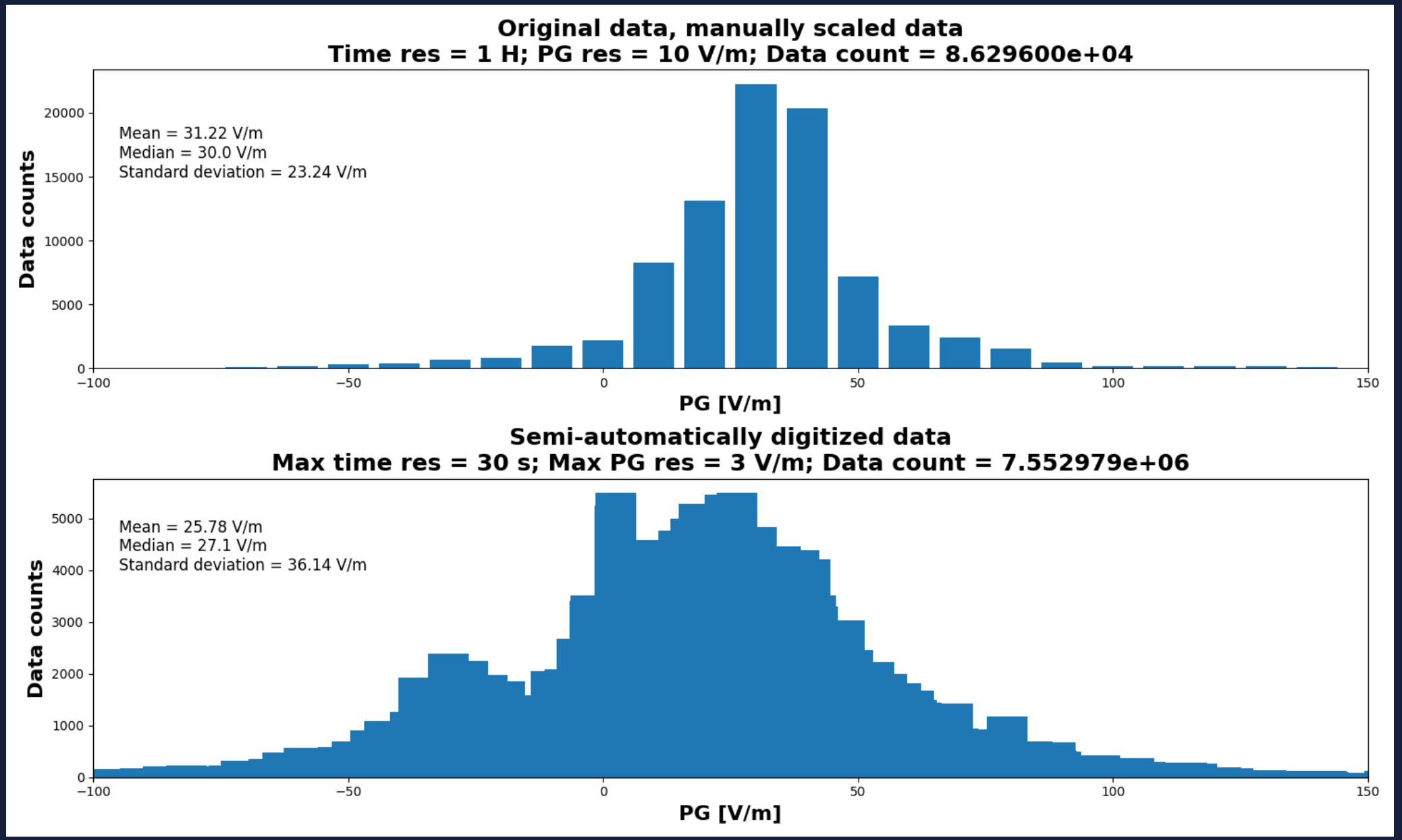


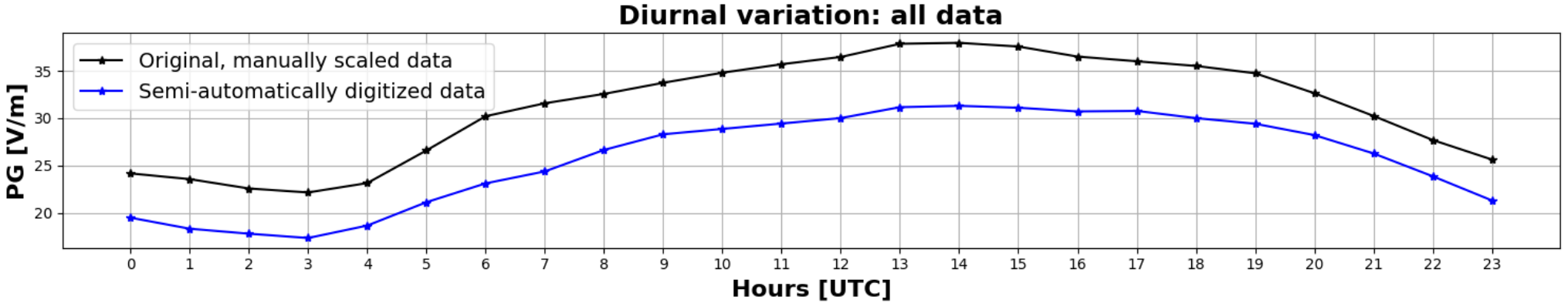
Image processing algorithm

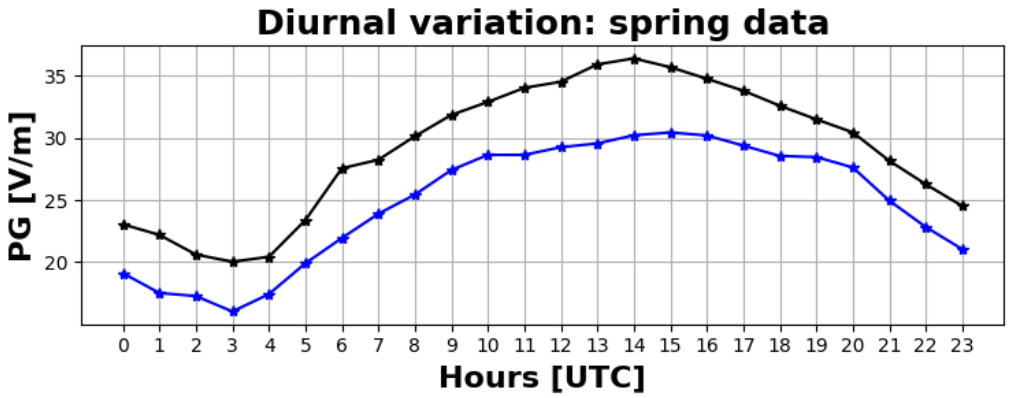


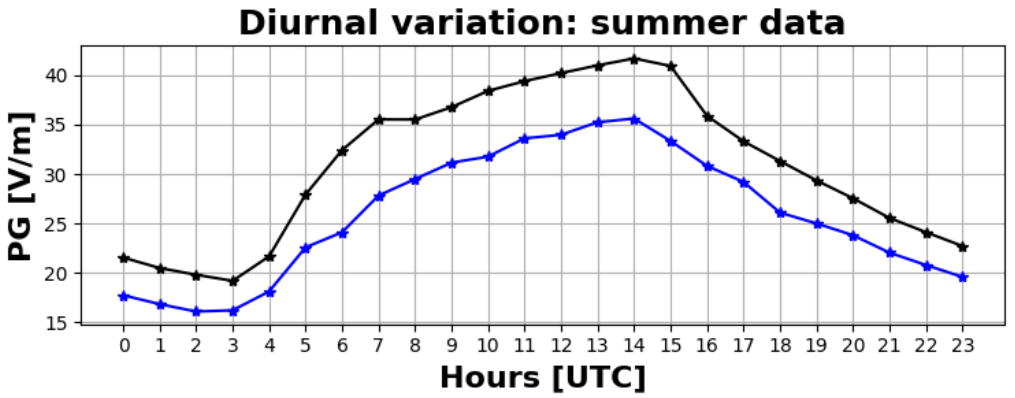
Validation

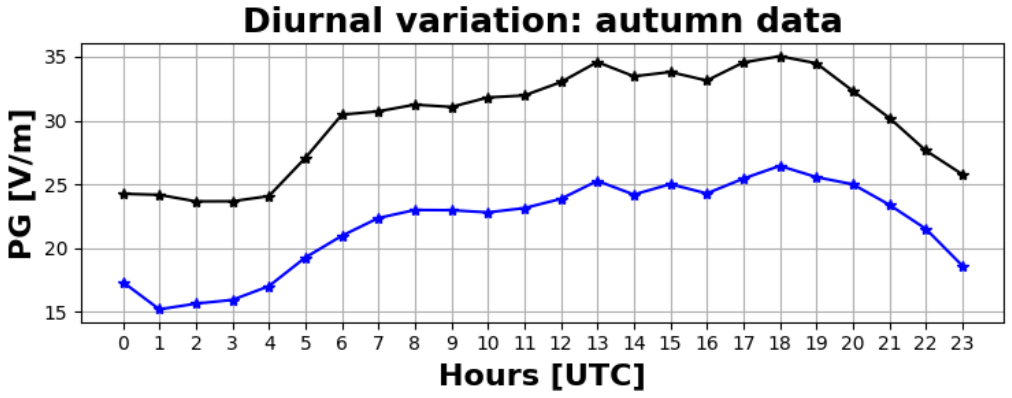

Original data, manually scaled data
Time res = 1 H; PG res = 10 V/m; Data count = 8.629600e+04
Mean = 31.22 V/m
Median = 30.0 V/m
Standard deviation = 23.24 V/m
Data counts
PG [V/m]
Semi-automatically digitized data
Max time res = 30 s; Max PG res = 3 V/m; Data count = 7.552979e+06
Mean = 25.78 V/m
Median = 27.1 V/m
Standard deviation = 36.14 V/m
Data counts
PG [V/m]

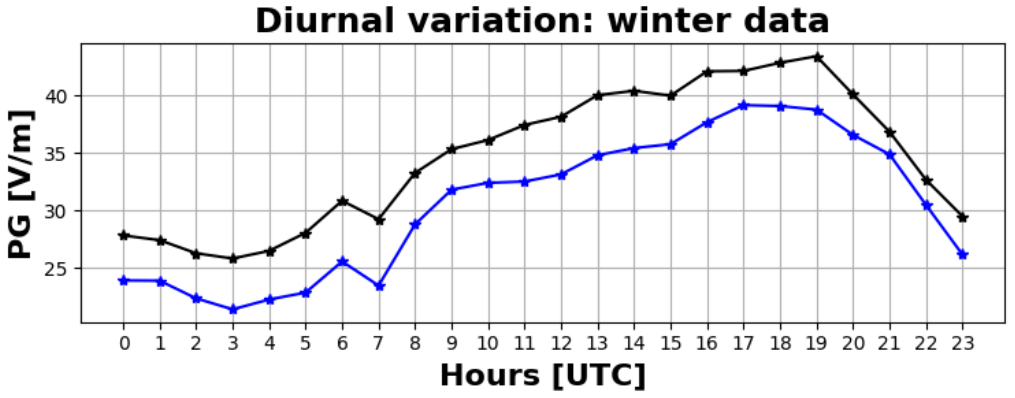
Validation


Diurnal variation: all data
Original, manually scaled data
Semi-automatically digitized data
PG [V/m]
Hours [UTC]


Diurnal variation: spring data
PG [V/m]
Hours [UTC]


Diurnal variation: summer data
PG [V/m]
Hours [UTC]


Diurnal variation: autumn data
PG [V/m]
Hours [UTC]


Diurnal variation: winter data
PG [V/m]
Hours [UTC]

Conclusions

- **The algorithm has proved to perform well on fair-weather PG data and produces high time resolution (~30 s) data** from the original, photographic records.
- **Resolution of the digitized data**: ca. 30 seconds, ca. 3 V/m.
- The **number of data points** increased by two orders of magnitude.
- **Runtime of the algorithm**: 30 seconds (digitization of a scanned image which contains weekly data set).
- **Compression rate**: 25x (10 MB picture -> 0,4 MB numerical value).
- **Plans for future**:
  - Code optimization,
  - digitizing images based on AI/deep learning solutions.

Thank you very much for your attention!

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