**Title:**

Automated detection and classification of hollow terrain shapes

* An approach to

**1. Introduction:**

Introduction of MOF area:

* Area
* Approach
* Goal

**2. Methods:**

General Information:

Pinge:

A *Pinge* is the name given in German-speaking Europe to a wedge-, ditch- or funnel-shaped depression in the terrain caused by mining activity.[[1]](https://en.wikipedia.org/wiki/Pinge#cite_note-1) This depression or sink-hole is frequently caused by the collapse of old underground mine workings that are close to the Earth's surface.[[2]](https://en.wikipedia.org/wiki/Pinge#cite_note-2)

1. Joachim Huske: Die Steinkohlenzechen im Ruhrrevier. 3rd edition, German Mining Museum, Bochum, 2006, ISBN 3-937203-24-9
2. Walter Bischoff, Heinz Bramann, Westfälische Berggewerkschaftskasse Bochum, In: Das kleine Bergbaulexikon. 7th edn., Verlag Glückauf GmbH, Essen, 1988, ISBN 3-7739-0501-7

Sinkhole:

A sinkhole, also known as a cenote, sink, sink-hole,[[1]](https://en.wikipedia.org/wiki/Sinkhole#cite_note-1)[[2]](https://en.wikipedia.org/wiki/Sinkhole#cite_note-2) swallet, swallow hole, or doline (the different terms for sinkholes are often used interchangeably[[3]](https://en.wikipedia.org/wiki/Sinkhole#cite_note-3)), is a depression or hole in the ground caused by some form of collapse of the surface layer. Most are caused by karst processes – the chemical dissolution of carbonate rocks[[4]](https://en.wikipedia.org/wiki/Sinkhole" \l "cite_note-4) or suffusion processes.[[5]](https://en.wikipedia.org/wiki/Sinkhole#cite_note-bgs-5) Sinkholes vary in size from 1 to 600 m (3.3 to 2,000 ft) both in diameter and depth, and vary in form from soil-lined bowls to bedrock-edged chasms. Sinkholes may form gradually or suddenly, and are found worldwide.[[6]](https://en.wikipedia.org/wiki/Sinkhole#cite_note-6)

1. Whittow, John (1984). Dictionary of Physical Geography. London: Penguin. p. 488. ISBN 978-0-14-051094-2.
2. Thomas, David; Goudie, Andrew, eds. (2009). The Dictionary of Physical Geography (3rd ed.). Chichester: John Wiley & Sons. p. 440. ISBN 978-1444313161.
3. Kohl, Martin (2001). "Subsidence and sinkholes in East Tennessee. A field guide to holes in the ground" (PDF). State of Tennessee. Retrieved 18 February 2014.
4. Lard, L., Paull, C., & Hobson, B. (1995). "Genesis of a submarine sinkhole without subaerial exposure". Geology. 23 (10): 949–951. Bibcode:1995Geo....23..949L. doi:10.1130/0091-7613(1995)023<0949:GOASSW>2.3.CO;2.
5. "Caves and karst – dolines and sinkholes". British Geological Survey.
6. Kohl, Martin (2001). "Subsidence and sinkholes in East Tennessee. A field guide to holes in the ground" (PDF). State of Tennessee. Archived from the original (PDF) on 12 October 2013. Retrieved 18 February 2014.

Explosion crater:

1. P. W. Cooper. *Explosives Engineering*. Wiley-VCH. [ISBN](https://en.wikipedia.org/wiki/International_Standard_Book_Number) [0-471-18636-8](https://en.wikipedia.org/wiki/Special:BookSources/0-471-18636-8)

* Remote sensing

Flowchart graphic: (LIDAR->DEM->SOM->Segmentation->Artificial layers->Extraction->ordination->test validation and prediction)

* + Based on Lidar-data (hessisches bundesamt bla)
  + Generation of an digital elevation model (DEM)
  + Calculation of an sinks only model (SOM)
  + Segmentation of hollow terrain shapes (including validation and point layer)
  + Generation of artificial layers based on morphometrics (aspect, slope etc.) and sky-view factor
  + Extraction of artificial layers values (pixel-based) using the polygons generated by the segmentation (mathematical operation included)
  + Training area selection (pinge, sinkholes, explosion craters) (Sources)
  + Perform workflow on training area
  + Ordination and cluster analysis
  + Cluster statistics
  + Internal validation -> test on all classes
  + Prediction MOF

**Training Areas**

The first step is the creation of an digital elevation model (DEM) out of a LIDAR-pointcloud for each training area (pinge, sinkholes, explosion craters).

The “Legion DEM” function creates multiple artificial layers (aspect, slope, coverture, skyview) from the DEM. The “Cenith fillsinks” function is applied to calculate a sinks only model (SOM). The “Cenith hollow” function performs a segmentation of hollow terrain shapes (based on Foresttools algorithm).

A point-layer with supervised terrain shape positions was created to validate the segmentation results. This is necessary because only objects which are for sure the desired class (pinge, domina, explosion crater) and no other shapes.

In order to avoid the creation of too small or too big polygons a minimum and maximum polygon size was defined to keep out non matching terrain shapes. Also a minimum height of 0.1m was applied...

The calculated polygon segments are used by the “Reaver extraction” function to extract the mean and standard deviation pixel-values from each of the previously generated artificial layers.

After this step every segment has the mean, and standard deviation values associated for each artificial layer. The data get stored in a dataframe.

The dataframes for all training areas are merged into one dataframe. In order to calculate a ordination the negative values were converted into positives.

**Study Area**

Study areas:

Pinge: Neu-anspach

Explosion craters: Lahnberge

Sinkholes: Bad Drieburg

* Field methods

**3. Results:**

**4. Discussion/Conclusion/Outlook:**

**5. Literature**