Image Hub Explorer: Evaluating Representations and Metrics for Content-based Image Retrieval and Object Recognition

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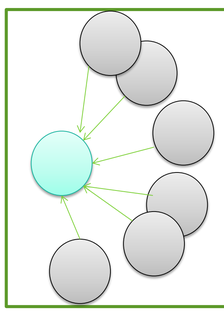
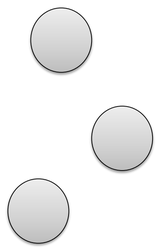
HUBS: WHERE AND WHY

- Hubness occurs in all intrinsically high-dimensional data, including images and text.
- Hubs emerge as centers of influence within the data and dominate the query result sets.
- They are less relevant to the queries and frequently violate the semantics of the search.
- Hubness is related to distance concentration and other aspects of the dimensionality curse. Different feature representations and different metrics exhibit different degrees of hubness.



HUBS: unusually frequent nearest neighbors, similar to many other points.

Their occurrences are often not informative and act as noise.

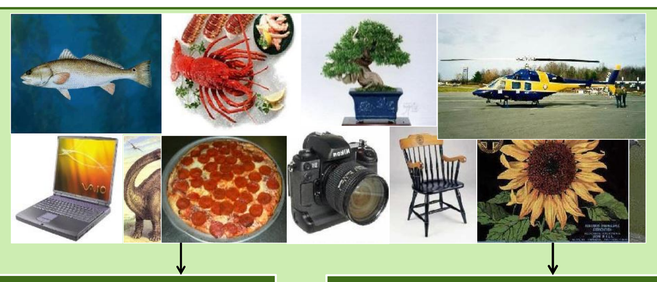


ORPHANS: Points that are never retrieved in *k*NN queries.

Most points in high-dim. data are orphans, which leads to an information loss.

IMAGE HUB EXPLORER

- Aimed at system developers and IR/OR researchers
- Provides easy ways to visualize the centers of influence within the data
- Makes it easy to detect the main semantic singularities
- Supports a wide range of metrics and supports metric learning.
- Allows for classification / object recognition
- Allows for querying and re-ranking
- Enables the users to evaluate the visual words and visualize them on images
- Helps in examining the local sub-graphs and visualizing interesting subsets of the data



Feature Representations ↔ Similarity Measures

Similarity Measures → k-NN topology

k-NN topology → Analyze

Analyze → Evaluate

Evaluate → IR/OR System Performance

MAIN GOALS

Visualize large image collections

Detect and Examine the centers of influence as major hubs within each class

Interpret the observed patterns by performing feature assessment

Solve the problems by finding the optimal metric and feature representation and by using the hubness-aware methods

SYSTEM ARCHITECTURE

Image Hub Explorer is built on top of the **Hub Miner** library, a data mining library implemented in Java, designed primarily for evaluating nearest neighbor methods in intrinsically high-dimensional data. The Hub Miner library is due to be released mid-2014. as open source.

Image Hub Explorer uses the following packages and interfaces from Hub Miner:

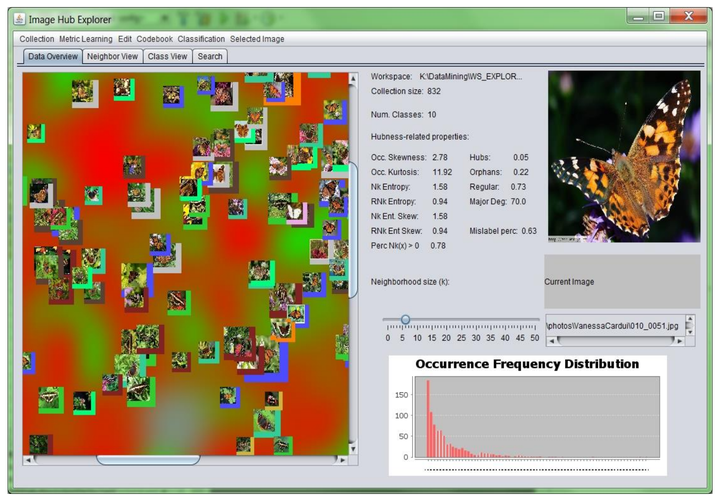
- Metric learning
- Hubness analytics
- *k*NN search
- Data visualization
- Classification
- Ranking

The remaining current capabilities of the Hub Miner library include the following: clustering, hubness-aware learning, anomaly detection, feature evaluation, stochastic optimization, text processing and analytics and statistics.

There are also a few external dependencies. Multidimensional scaling is performed by the **MDSJ** library developed at the University of Konstanz. Graph drawing is performed by the **JUNG** library (http://jung.sourceforge.net/). Charts that are used to illustrate certain data properties are displayed via **JFreeChart** (http://www.jfree.org/jfreechart/).

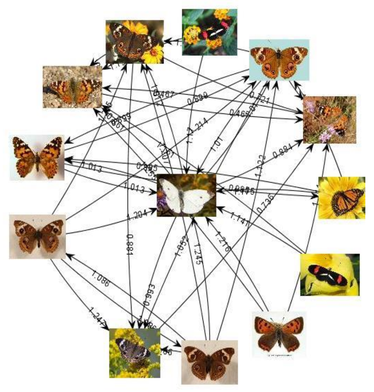
DATA OVERVIEW

- Main hubs are projected onto a viewing pane by multi-dimensional scaling.
- The average induced label mismatch percentages in *k*NN sets are used to determine the background landscape, which is smoothed by multiple passes of low-level convolution filters.



- Images can be selected and analyzed in other views.
- The main properties of the *k*NN topology are summerized for the currently selected metric and representation
- The interactive *k*-slider allows for a quick inspection of different neighborhood sizes
- Different metrics and reps can be selected from the menus above

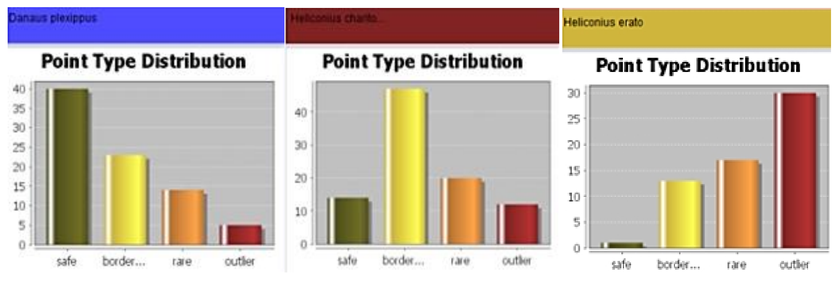
EXAMINE INDIVIDUAL HUBS



- The Graph View allows for a selection of direct and reverse nearest neighbors of each point, which can be added to the view. Their neighbors can also be selected, etc. This way, users can form a local *k*NN sub-graph and examine its structure.
- Here is an example of a bad hub from the butterfly image data. The *Artogeia rapae* image in the middle is a nearest neighbor to many images from different classes, i.e. different butterfly species. This is not a feature of the image itself, but a consequence of the specific **feature representation** and **metric**. We can then change metrics and go back and select the same image and observe how the structure has changed.

FEATURE ASSESSMENT

POINT TYPE DISTRIBUTIONS



- Different classes consist of different types of points, so some are more difficult to handle than others
- IHE makes it easy to visualize this

OBJECT RECOGNITION AND RANKING

Image Hub Explorer implements several novel approaches to hubness-aware learning and classification, as well as re-ranking. It also implements several standard baselines. These components can be evaluated for each rep./metric choice.

IMAGE DATA IN THE EXAMPLE: LEEDS BUTTERFLY DATASET

The data can be accessed at: http://www.comp.leeds.ac.uk/scs6jwks/dataset/leedsbutterfly/

Wang, J., Markert, K., Everingham, M.: *Learning models for object recognition from natural language descriptions*. In: Proceedings of the British Machine Vision Conference. BMVA Press, London, UK (2009)

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CONTACT

For more information on our work on **hubness**, visit: **http://ailab.ijs.si/nenad_tomasev/**