Advanced Topics in Image Understanding

Picture Classification

Student Project

Purpose

- To be able to independently carry out a small group project
- To understand and (partially) master the difficulties of a non-trivial analysis problem
- To be able of working in a group (distributing and coordinating a common work effort)
- To be able to present scientific work to the public

Organisation

- **Step 1**: Date organisation (3 weeks)
  - Getting acquainted with the test data (& website)
  - Organising the data in a way suitable for training and test
  - First ideas about suitable features

  Short presentations: May 3
- **Step 2**: Selection of a classification technique (4 weeks)
  - Decision on feature space and classifier
  - Implementation of a classification technique Short presentations: May 31

(June 15: last lecture)

Organisation

- **Step 3**: Finalisation (4 weeks)
  - Adaptations, changes and tests (3 weeks)
  - Preparation of a final presentation (1 week) Final Presentation: June 28

  Reports (5 pages) submitted by June 26 (pdf-File)

Additional Information

- Choose programming language that suits you best
  - C++, MATLAB, …
  - There will be no support regarding programming techniques!
- Classification methods
  - Some simple methods (e.g. kNN) can be implemented easily
  - MATLAB, Octave, OpenCV offer basic classification tools
  - WEKA 3 (http://www.cs.waikato.ac.nz/ml/weka/) is open source software that includes all common (and some uncommon) classification tools

Requirements for Successful Participation

- Successful project
  - Selection and implementation of a meaningful feature descriptor
  - Selection and implementation of a meaningful classification method
  - Training and tests with 25% successful classifications (or better)
- Participation in the Milestone meetings
  - Each group member should give at least one presentation (either intermediate or final)
- Final presentation
  - Justification of selected strategies
  - Discussion of achieved results (what is good, what not so good and why)
- Report (5 pages summarizing and discussing implementation and results)

The Problem

- Classifying arbitrary pictures is a very hard problem
  - The so-called *semantic gap* between pixel colors and desired image semantic
  - An image contains too many features (pixels) to be useful input for most machine learning methods
  - Semantics stem from an unknown subset of pixels
- CalTech101 is a reference dataset to test image classification methods

Images of the Caltech101 dataset

The CalTech 101 dataset

- ***www.vision.caltech.edu/Image_Datasets/Caltech101/***
- contains 101 different image categories
- contains 30-80 sample images for each category
  - the meaning (class) of a picture is always depicted by a single, often frame-filling object (this is a simplification!)
  - depicted objects may be photos, sketches, or drawings (this is a
  - difficulty)
- goal is to correctly classify as many pictures as possible
  - random classification would result in ~1% success rate
  - current best methods achieve more than 95% success

Sample class

- pictures are small (<<1MPixel)
- objects differ in colour, size, orientation, shape
- still easily recognisable by human
- consequences
  - template matching strategy will not work (too many variations)
  - training pixel values will not work (too many pixels)

Questions

- Is it possible to sucessfully (>25%) classify the data set?
  - which features (data has to be reduced but how)
  - which feature selection process
  - which classification strategy
- Feature vector AND classification strategy will contribute to the success
  - even efficient features may cluster unevenly in feature space

The Feature Descriptor

- Selection of a feature descriptor
  - remember lectures 2, 3, and 4, also look around (web)
  - measure should be discriminating (use test data)
  - try to avoid descriptor that reflects artefactual (hence unneccessary) variation
  - measurement vector should not contain unnecessary information (look at the influence of the different features, consider feature reduction techniques, lecture 5)
- Justification of selected measure
  - Try to make some assumption as to why a selected measure / a selected feature set should be appropriate (possibly after the fact)

Classification

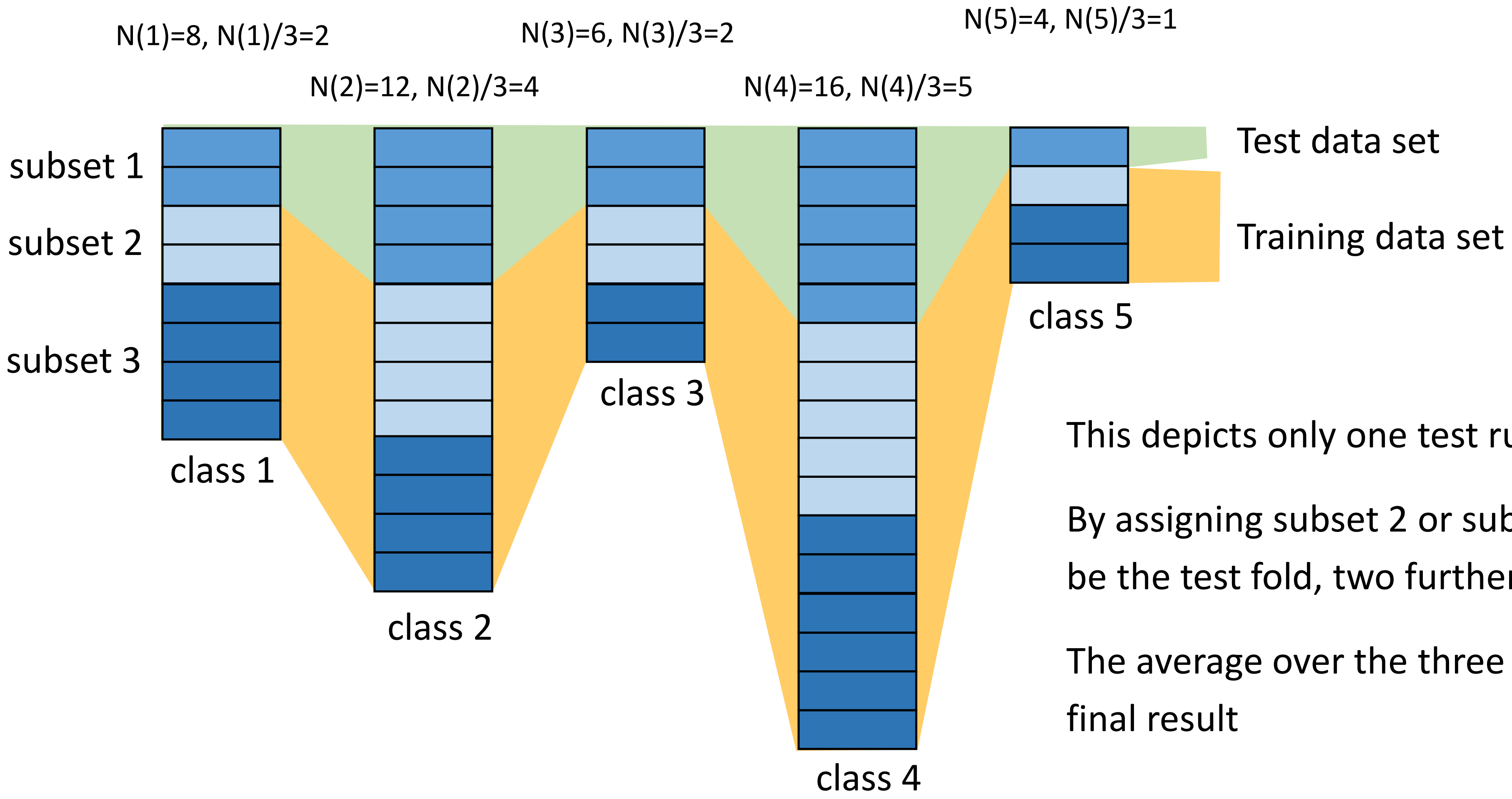
- Clustering can be used for class detection (lecture 7)
- Even simple classifiers (such as kNN) should produce some success, if useful features are selected
    - – If distribution in feature space is complex, classification techniques that create irregular class boundaries (lectures 8,9) may be helpful.
    - - Deep learning (lectures 10-13) is applicable as well but requires a lot of experience and background knowledge

Testing the classifier

Test by 10-fold cross-validation

- Create 10 subsets from each class
  - enumerate samples for each class k by s(i,k), where i=1,N(k) is the sample of the k-th class
  - Create class-specific subsets s1,… s10, with indices 1,…,d(k), d(k)+1…2d(k), etc. (where the dividers are d(k)=N(k)/10 and the last subset s10 with indices 9d(k)+1…N(k) may contain more samples than the other subsets)
- Cross-validation
  - remove a single fold from all class-specific folds and use the remaining folds for training the classifier
  - Test the classifier on the removed fold
  - Repeat for all 10 combinations of training / test sets

The folds (example 3-fold CV, 5 classes)



This depicts only one test run!

By assigning subset 2 or subset 3, respectively, to be the test fold, two further tests can be made.

The average over the three tests produces the final result

Some Hints: Test Data

- Set up a training and test scenario, possibly group data
  - by complexity
  - by content
  - It may be useful to start with fewer than the full 101 categories
- Selecting test data and setting up scenario can be done parallel to feature selection implementation
  - clever distribution of work among group members
  - still requires communication (feature selection may pose constraints that need to be met by test data)

Some Hints: Intermediate Presentations

- Purpose is
  - to document the work in the weeks before
  - to open it to discussion with the other groups
  - to get input from the other groups
- What should be presented
  - decisions and their justification (do assume that everybody else has similar general experiences; go into detail regarding specifics only)
  - experiences (do try to explain why what worked and why you think other
  - things did not work)
  - prepare examples beforehand that explain a certain behaviour
- Duration: 10-15 min. including discussion

Some Hints: Final Presentation

- Short presentation (15 minutes)
- Do assume that general idea of your project is known to audience
- Contents
  - Short summary of design decisions
  - More detailed presentation on any specific adaptations
  - Presentation of results
  - Discussion of results w.r.t. selected methods and adaptations

Some Hints: Report

- Description of the problem (based on the sample images)
- Decision on features (justification, the measure itself)
- Classification details
- How the classifier was trained
  - Training details
  - Results (i.e. how good on training data, hints for subgroups, validity of features,…)
- Tests on independent test data
  - Description of the test scenario
  - Results and any conclusions from that
- Conclusions (how would you rate your approach)