

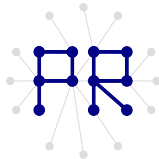
Pattern Recognition Lecture

“Template Matching”

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- In previous lectures, the major concern was to assign an unknown pattern to one of the possible classes.
- Now, we assume that a set of reference patterns is available to us, and we have to decide which one of these reference patterns matches best the unknown pattern (test pattern).
- A reasonable first step in approaching such a task is to define a measure or a cost measuring the distance or the similarity between the known reference patterns and the unknown test pattern.

An Example Tool for Image Similarity Measure

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K-Space Content Management and Retrieval System - Microsoft Internet Explorer

File Edit View Favorites Tools Help

Back Forward Stop Search Favorites

Address <http://138.37.33.138:9759/> Go Links

K-Space Document Navigation

View	Document title & abstract	Transcode	Shot edition	Semantic annotation	Visual search
	shakira legs dont lie "Hips Don't Lie" is a Grammy Award-nominated Latin pop song performed by Colombian singer Shakira and Haitian rapper Wyclef Jean. The music video has direct...				
	shred someone nothing compares to you "Nothing Compares To You" is a song written around 1984 or 1985 by Prince for The Family, a funk band created as an outlet to release more of his music. Five...				
	Intony spears baby one more time Shot at Venice High School in California, the scenario begins with Spears in a particularly boring class right before the end of the day. Her assistant Falc...				
	moloko sing it back... ...le songs, and its music video, popular on MTV in dancing and performing the song in a bright white sing alone in a metallic flapper dress, accompanied heup included Rob Hirst on drums, Peter Garnett on er in white room and singing a slow song about her the group of men dressed in black suits. Video from Düsseldorf, and Andi Toma, from Köln) who Journalist: Ministry of Defence and Tony Blair conference. Angela Merkel is joining the rally. in: Duel between Jan Ulrich and Lars Armstrong is				
	News journal4 Schneider speaking with Romano Prodi in Berlin about the European Union Stability pact. They are standing in front of Brandenburg Gate in Berlin commenting L...				
	News journal5 Ulrich Barth Deutsche Welle journalist speaks about mobile phones market. Business news. Ericson				

Create content ...
Input content
Process content
Current tasks

Content Retrieval ...
Navigate
Search

Auxiliary tasks ...
User Profile
Help

Home
Logout guest

<http://138.37.33.138:9759 - View Document 'moloko sing it back...>

Done Internet

Start 1:138.37.33.126 - m... 2:138.37.33.126 - m... K-Space Content Ma... http://138.37.33.1... images Kspace_system - Win... 10:13 AM

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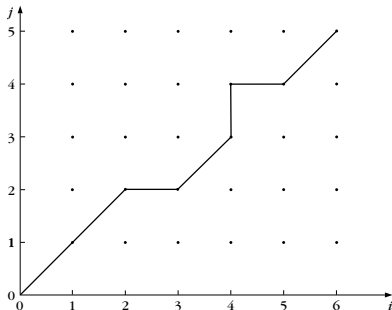
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- Here, the focus is on a category of template matching, where the involved patterns consist of strings of identified symbols or feature vectors (string patterns).
- Each of the reference and test patterns is represented as a sequence (string) of measured parameters and one has to decide which reference sequence matches best the test pattern.
- Let $\mathbf{r}(i), i = 1, \dots, I$ and $\mathbf{t}(j), j = 1, 2, \dots, J$ be the respective feature vector sequences for a specific pair of reference and test patterns. In general $I \neq J$.
- The objective is to develop an appropriate distance measure between the two sequences.

Approach in General (1)

- We form a two-dimensional grid with the elements of the two sequences as points on the respective axes. Example for $I = 6$ and $J = 5$ looks like follows:



- Each node (i,j) is associated with a cost (distance) $d(i,j)$.

Approach in General (2)

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- The path from the initial to a final node is an ordered set of nodes

$$(i_0, j_0), (i_1, j_1), (i_2, j_2), \dots, (i_f, j_f)$$

- Each path is associated with an overall cost D defined as

$$D = \sum_{k=0}^{K-1} d(i_k, j_k) \equiv D(i_k, j_k); \quad D(0, 0) = 0$$

where K is the number of nodes along the path.

- The path is complete if $(i_0, j_0) = (0, 0); (i_f, j_f) = (I, J)$.

Approach in General (3)

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- The distance between the two sequences is defined as **the minimum D over all possible paths.**
- At the same time, the minimum cost path unravels the pairwise correspondence between the elements of the two sequences.

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- The major task to be addressed in this section can be summarised as follows: “Given a block of recorded data, find whether a specific known reference pattern is contained within the block and where it is located.”
- A typical application of this is found in scene analysis, when we want to search for a specific objects within the image.

Approach in General (1)

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- Given are a reference pattern expressed as an $M \times N$ image array $\mathbf{r}(i, j)$ and $I \times J$ image array $\mathbf{t}(i, j)$, where $M \leq I$ and $N \leq J$.
- The goal is to develop a measure for detecting an $M \times N$ subimage within $\mathbf{t}(i, j)$ that matches best the reference pattern $\mathbf{r}(i, j)$.

Approach in General (2)

- The reference image $\mathbf{r}(i, j)$ is superimposed on the test image $\mathbf{t}(i, j)$ and it is translated to all possible positions (m, n) .
- For each of the points (m, n) , the mismatch between $\mathbf{r}(i, j)$ and the $M \times N$ subimage of $\mathbf{t}(i, j)$ is computed according to

$$D(m, n) = \sum_{i=m}^{m+M-1} \sum_{j=n}^{n+N-1} |t(i, j) - r(i - m, j - n)|^2$$

- The template matching algorithm looks for the location (m, n) for which $D(m, n)$ is minimum.

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- By now we have been looking for the perfect match between the reference and the test pattern.
- However, there are many problems where we know a priori that the available template and the object we search for in the image may not look exactly the same (remember the demo with the system for sketch-based image retrieval).
- Our goal here is to allow the template matching procedure to account for deviations between the reference template and the corresponding test pattern in the image.
- Thus, we will focus on shape information only.

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Approach in General (1)

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- The basic idea is simple: Deform the prototype and produce deformed variants of it.
- From a mathematical point of view a deformation consists of the application of a parametric transform T_ξ on $\mathbf{r}(i, j)$.
- Different values of ξ lead to different versions.
- From the set of the deformed prototype variants that can be generated, there will be one that best matches the test pattern.

Approach in General (2)

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- The goodness of fit is measured via a cost which is called the matching energy $E_m(\xi)$.
- The cost measuring the deformation, which the prototype needs to undergo in order to fit the test pattern is called the cost deformation energy $E_d(\xi)$.
- The optimal vector parameter ξ is chosen so that the best trade-off between these two energy terms is achieved.

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General about CBIR

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- The more traditional way of information retrieval is text-based; stored information is manually annotated by text descriptors.
- In CBIR, stored information is indexed and searched based on its content.

A Popular Metric for CBIR

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- A popular metric that has extensively been used for CBIR is

$$d(\mathbf{x}, \mathbf{y}) = \left(\sum_{i=1}^I \omega_i |x_i - y_i|^p \right)^{\frac{1}{p}}$$

- Obviously, for $p = 2$ and $\omega_{i=1,2,\dots,I} = 1$ this becomes the Euclidean distance and for $p = 1$ the so called weighted l_1 (Manhattan) norm.

Content-Based Video Retrieval System

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	visual searcher nothing compares to you "Nothing Compares To You" is a song written around 1984 or 1985 by Prince for The Family, a funk band created as an outlet to release more of his music. Five...				
	Intony spears baby one more time Shot at Venice High School in California, the scenario begins with Spears in a particularly boring class right before the end of the day. Her assistant Falc...				
	http://138.37.33.138:9759 - View Document 'moloko sing it back...				

The video player shows a performance by Moloko. The text 'MOLOKO SING IT BACK' and 'MUSIC FACTORY' is visible on the screen.

Below the video player, there is a table of search results with columns for 'View', 'Document title & abstract', 'Transcode', 'Shot edition', 'Semantic annotation', and 'Visual search'.

News journal4
Schneider speaking with Romano Prodi in Berlin about the European Union Stability pact. They are standing in front of Brandenburg Gate in Berlin commenting...

News journal5
Ulrich Barth Deutsche Welle journalist speaks about mobile phones market. Business news. Ericsson

Disadvantages of CBIR Systems

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- Search and retrieval are based on low-level features.
- Humans, being much more intelligent than the machines, utilise a number of so called high-level concepts when they recognise objects.
- This discrepancy is called semantic gap.

Relevance Feedback in CBIR - Intro

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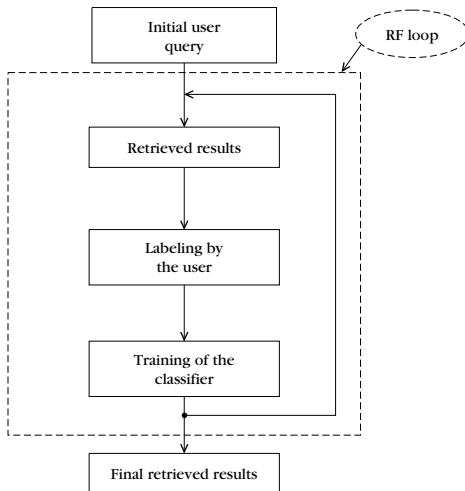
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- The mentioned problem with the semantic gap can partly be solved by involving the human into the retrieval process.
- The search/retrieval session is divided into a number of consecutive loops.
- At every loop, the user provides feedback regarding the results by characterising the retrieved patterns as either relevant or irrelevant.

Relevance Feedback in CBIR - a Typical Scenario



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Evaluation of the CBIR Systems

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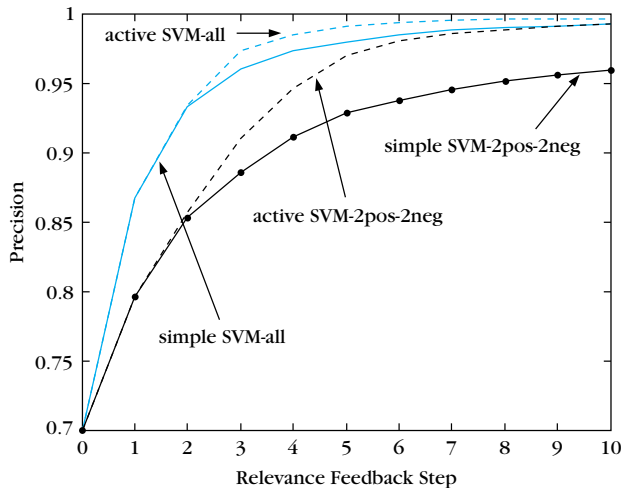
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- **Precision** is the ratio of relevant patterns to the total number of patterns in the set of returned patterns P_r .
- **Recall** is the ratio of returned relevant patterns to all relevant patterns in the database.

Evaluation of Different Strategies



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