

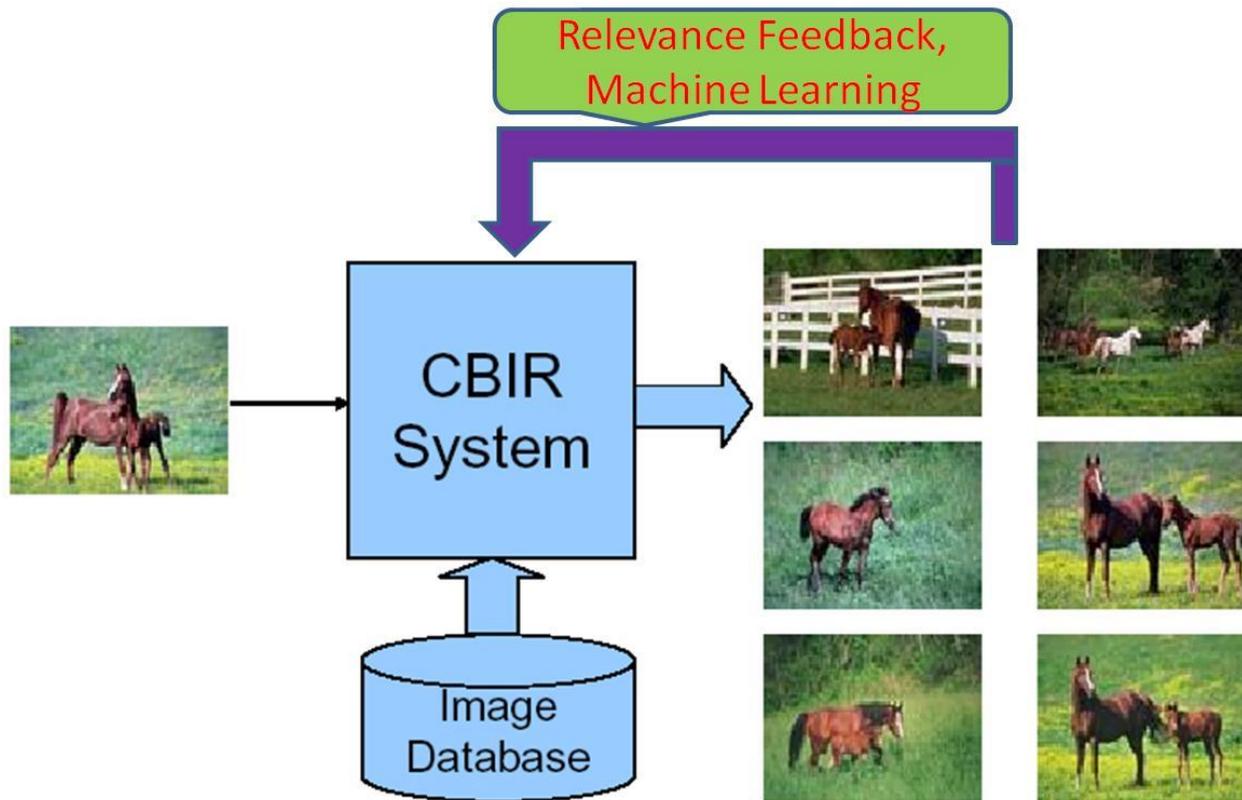
Indexação e Recuperação de Imagens por Conteúdo

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Content-based Image Retrieval (CBIR)



Roteiro

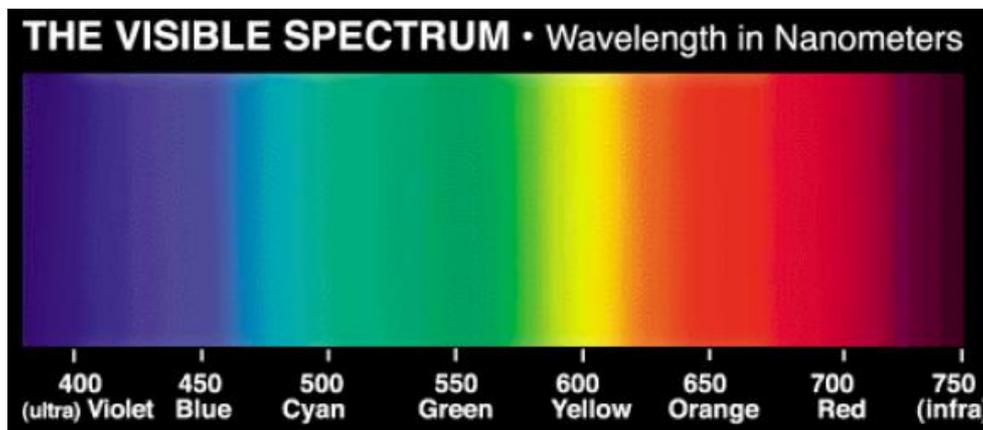
- Introdução
- Arquitetura
- Extração de Características
- Indexação
- Medidas de Similaridades
- Avaliação da qualidade
- Desafios
- Sistemas

Introdução

- Nós somos “criaturas visuais”;
- A maior parte das informações que adquirimos vem dos nossos olhos
- Cerca de 90 a 95% da informação que usamos no dia-a-dia vem do sistema visual

Introdução

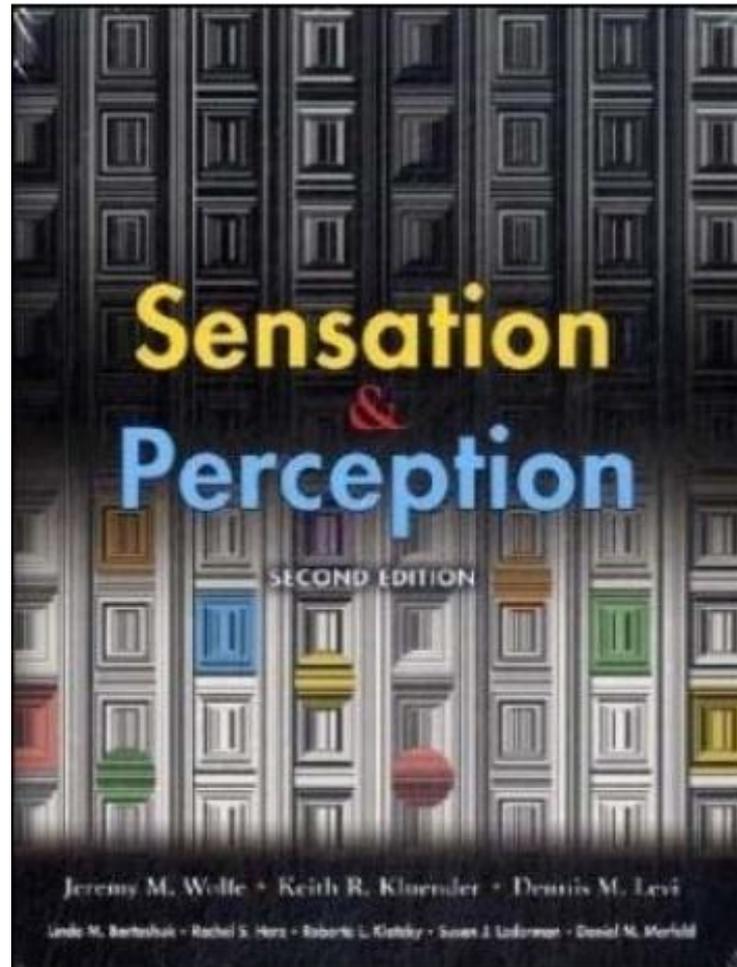
- Nossa visão depende de dois olhos frontais que detectam luz dentro de um conjunto específico de comprimentos de onda
 - Azul ao vermelho
 - Derivado dos primatas



Introdução

- Algumas culturas fixam sua atenção em um (ou poucos) objetos que estão no primeiro plano, ignorando os arredores
- Outras prestam mais atenção na cena completa e nos detalhes do background, notando a presença de objetos no primeiro plano, mas sem devotar muita atenção em seus detalhes
- Também o reconhecimento de um objeto em uma cena diminui (ou aumenta) nossa atenção (ou foco)

Introdução



Introdução

- Com o crescimento dos diversos dispositivos de aquisição de imagens em meios digitais, tanto para uso pessoal quanto equipamentos de uso profissional, surgiu a necessidade do desenvolvimento de técnicas de recuperação;
- Na década de 80 é considerada a etapa inicial dos estudos envolvendo CBIR;

Introdução

- As imagens digitais, entretanto, constituem dados complexos cujo conteúdo pode ser interpretado de diversas maneiras. Com isso podemos levantar diversos questionamento, exemplo:
 - Como interpretar ou representar o conteúdo de uma imagem?
 - Quais medidas que podem caracterizar adequadamente este conteúdo?
 - Como recuperar imagens de um grande repositórios utilizando o conteúdo extraído?
 - Como estabelecer um critério de similaridade entre estas imagens?

Introdução

■ Exemplo

- Um médico diante de um exame pode querer consultar outros exames parecidos com a intenção de reforçar o seu parecer clínico sobre um caso em análise;
- Um hospital-escola, os alunos de medicina podem recuperar imagens similares de diversos pacientes visando compreender o padrão de uma determinada doença.

Introdução

- Os sistemas de recuperação de imagens baseado em conteúdo (CBIR) permitem a recuperação de imagens utilizando características como:
 - Cor;
 - Textura;
 - Forma.

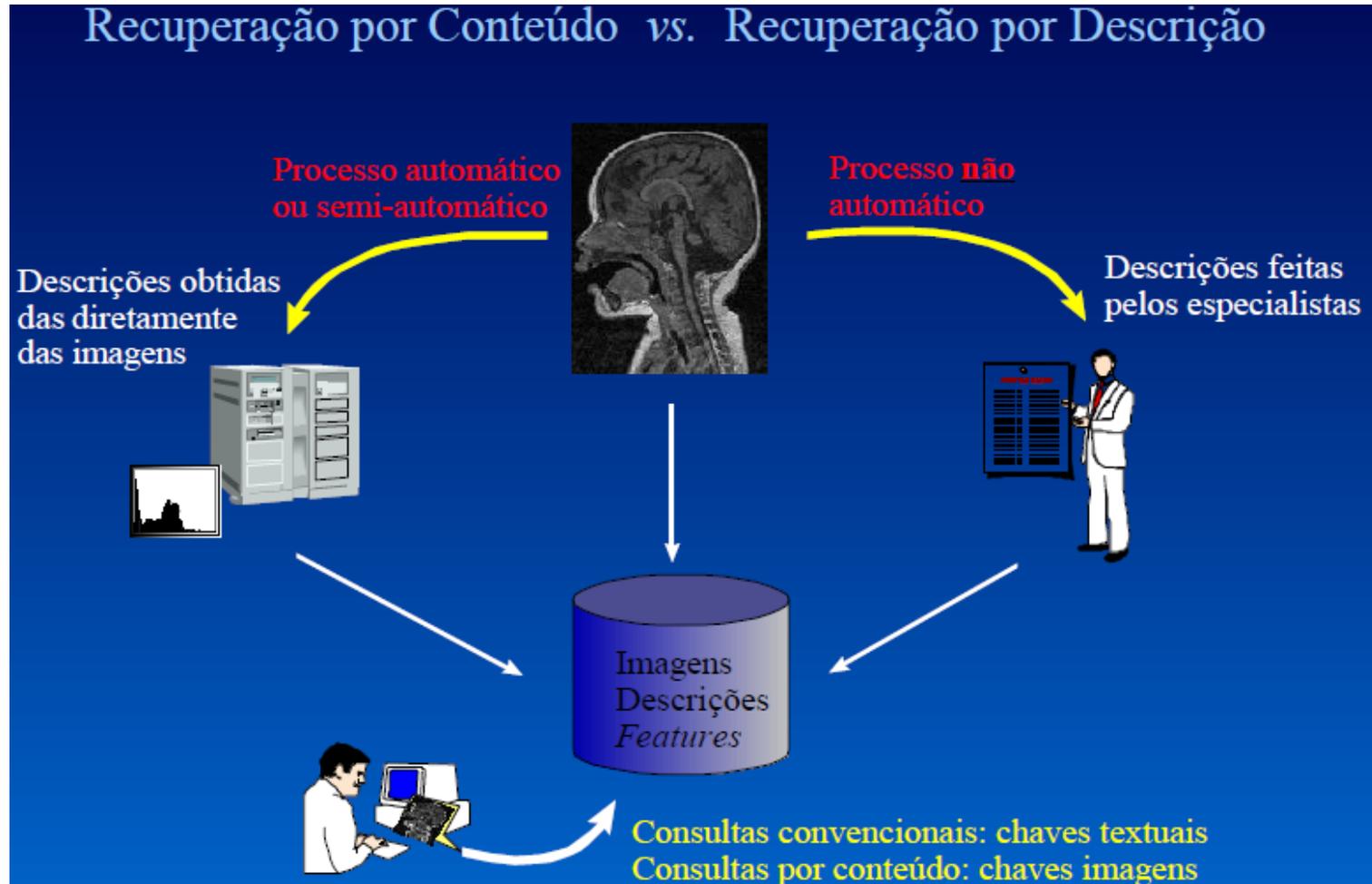
Introdução

- A pesquisa em CBIR pode ser classificada em três tipos:
- Recuperação por desenho (sketch): neste tipo de pesquisa, o usuário esboça uma imagem aproximada daquilo que ele deseja recuperar;
- Recuperação por exemplos (QBE – Query By Example): é a forma mais comum nos sistemas atuais. Nela, o usuário fornece uma imagem de exemplo, similar à qual ele deseja recuperar;

Introdução

- Busca Parametrizada: O usuário fornece parâmetros de busca que descrevem a imagem. Por exemplo, 'buscar imagens com 60% de vermelho e 40% de verde'.

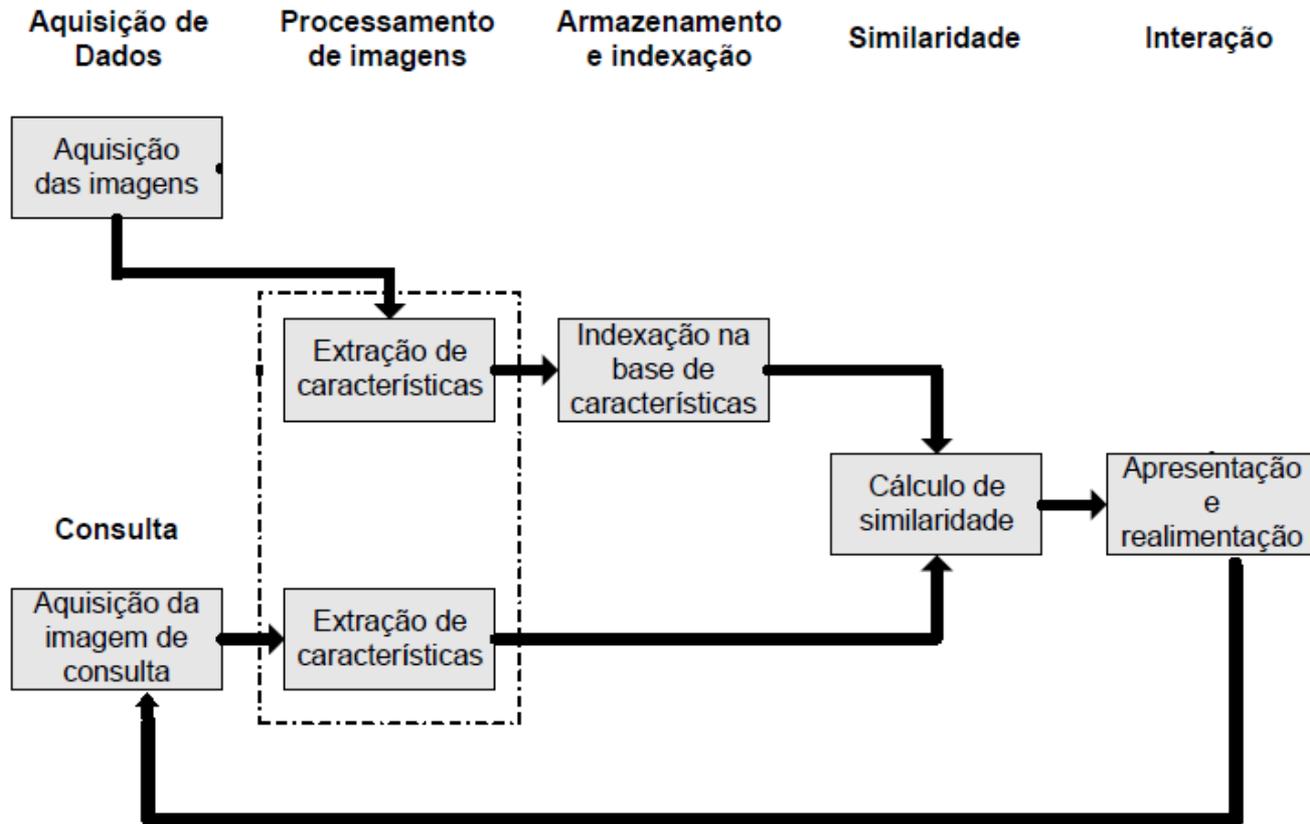
Introdução



Arquitetura

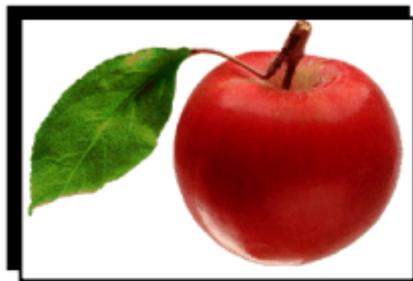
- Os sistemas de recuperação baseada em conteúdo são sempre compostos dos seguintes módulos:
- Interface gráfica de consulta
- Sistema de armazenamento e indexação de dados
- Medida de similaridade
- Extração de características e
- Sistema de recuperação (retrieval engine).

Arquitetura



[Extração de Características]

- Característica é uma função de uma ou mais medidas, calculadas de forma que quantifique alguma propriedade de um objeto.



*Imagem
Original*

**Extração de
Características**



*Vetor de
Características*

X1
X2
⋮
⋮
XN

[Extração de Características]

- Tipos de consultas por conteúdo:
 - Tipo 1 - Extração de características primitivas;
 - “Encontre imagens semelhantes a uma dada imagem”
 - Tipo 2 - Características derivadas com algum grau de inferência lógica
 - “Encontre imagens de bicicletas”
 - Tipo 3 - Características abstratas que envolve raciocínio sobre a intenção do usuário
 - “Encontre imagens de pessoas alegres”

[Extração de Características]

■ Cor

- Características baseadas em cor são as mais utilizadas em recuperação por conteúdo;
- As cores podem ser representadas em diferentes sistemas. Entre eles:
 - RGB (red, green, blue) que é um modelo que mapeia diretamente as características físicas do dispositivo de exibição;
 - HSI (hue, saturation, intensity) que reflete mais precisamente o modelo de cores para a percepção humana.

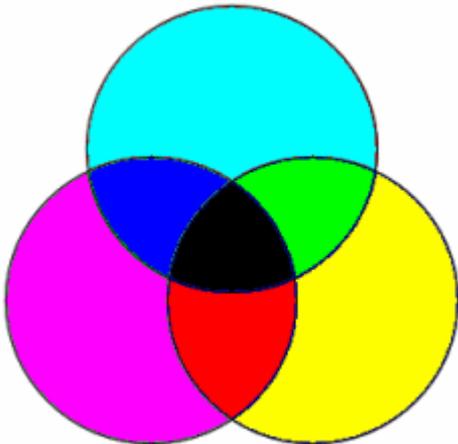
[Extração de Características]

■ Cor

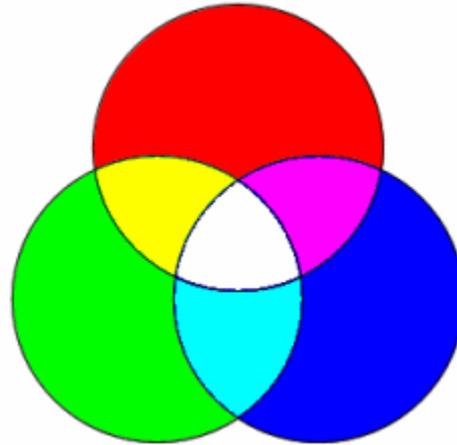
Escala de cinza



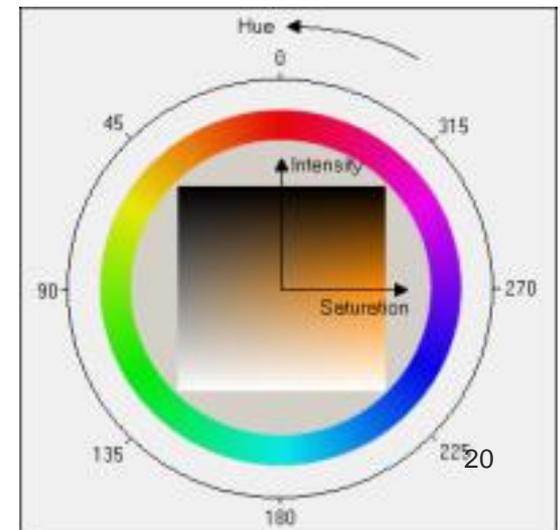
CMYK



RGB



HSI

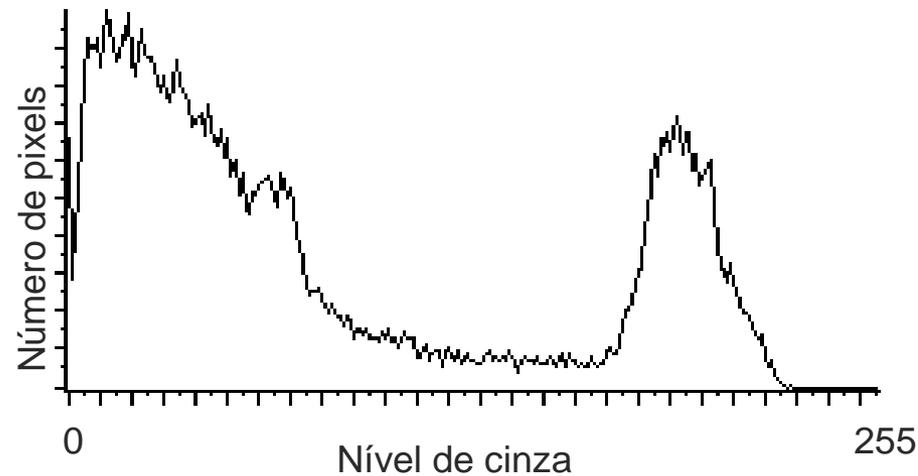


Extração de Características

- Cor
 - Histograma
 - Os histogramas são uma das formas mais usuais de medir a distribuição estatística de cores da imagem e a quantidade de pixel existente para cada cor, pois o cálculo é computacionalmente simples e barato e o histograma não é alterado caso ocorram pequenas alterações.

[Extração de Características]

- Cor
 - Histograma



Extração de Características

■ Cor

○ Histograma

■ Desvantagens

- Não apresenta informação sobre a distribuição espacial das cores. A solução é usar vetor de coerência, correlograma de cor, entropia da distribuição de cores, etc.
- É necessário grande espaço em memória para seu armazenamento. Uma das soluções é usar histograma métrico.

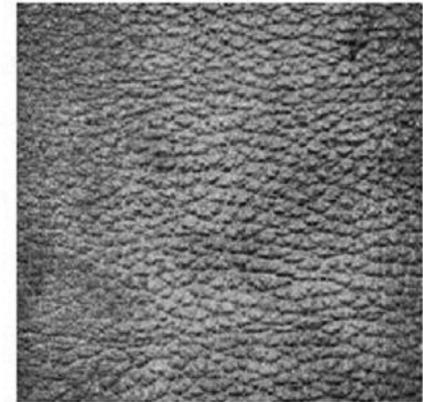
[Extração de Características]

■ Textura

- Textura é um atributo que representa o arranjo espacial dos níveis de cinza dos pixels em uma região
- Entre as técnicas para a extração de características de textura estão os filtros de Gabor e as Transformadas de Wavelets.
- Esses métodos tentam capturar partes da imagem com relação à mudança de direção e escala, e são muito úteis para imagens ou regiões com texturas homogêneas.

[Extração de Características]

- Textura



Extração de Características

■ Textura

- A extração de características de textura pode ser feita por um histograma, porém não se deve analisar somente a distribuição de intensidade de cores da imagem, mas também as posições relativas aos “pixels” com valores de intensidade iguais ou similares.

[Extração de Características]

■ Textura

- O histograma de segunda ordem (matriz de co-ocorrência) é uma representação da distribuição de probabilidade de ocorrência de um par de valores semelhantes separados por uma distância.
- A estatística desse histograma, como por exemplo, entropia, inércia e energia, correlacionam-se com as estruturas da imagem.

Extração de Características

■ Forma

- Toma como base a estrutura física dos objetos da imagem. Utiliza segmentação.



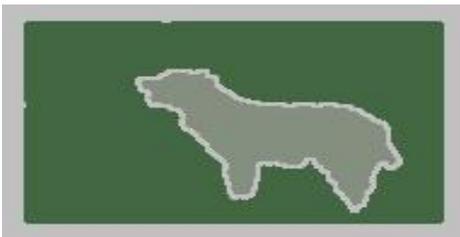
- Segmentação

- processo de dividir uma imagem digital em múltiplas regiões (conjunto de pixels) ou objetos;
- O objetivo é extrair objetos da imagem.



Extração de Características

- Forma
 - Segmentação



[Extração de Características]

■ Forma

- Após a segmentação, os segmentos resultantes podem ser descritos como vetores de características de forma que podem ter dimensão fixa ou variável.
- Métodos:
 - Curvature scale space;
 - Momentos de Zernike;
 - Transformada de Fourier.

Técnicas de indexação multidimensional

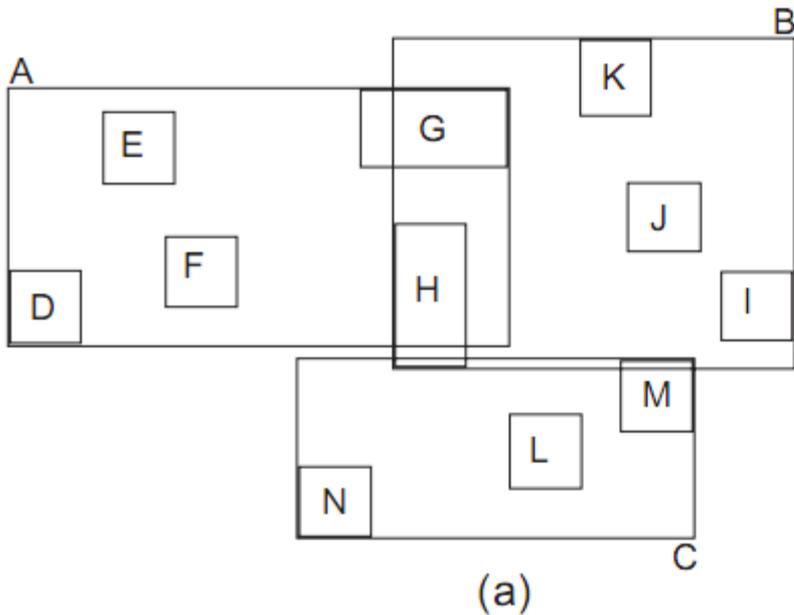
- Entre as técnicas de indexação multidimensional destacam-se:
 - Bucketing algorithm;
 - Kd-tree;
 - Priority k-d tree;
 - Quad-tree,
 - KD-B tree,
 - HB-tree;
 - R-tree e suas variantes RC-tree e R⁺-tree

Técnicas de indexação multidimensional

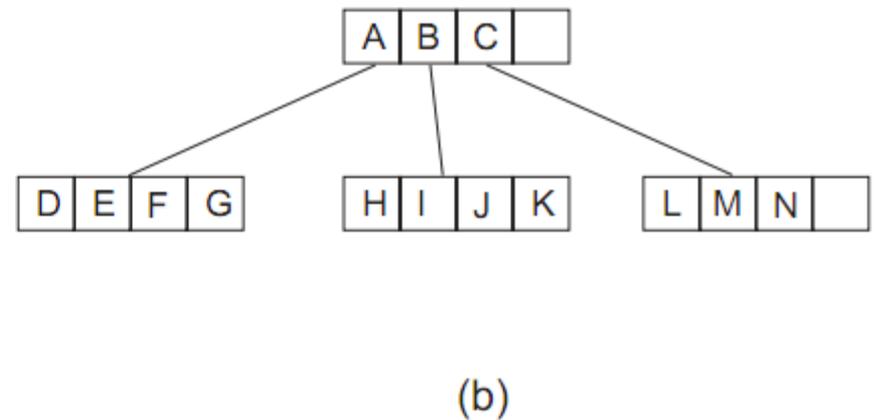
- R-Tree
 - O método R-tree é uma estrutura hierárquica baseada no método B-tree que permite a organização dinâmica de um conjunto de elementos geométricos de dimensão d pela representação de retângulos envolventes mínimos.

Técnicas de indexação multidimensional

■ R-Tree



Distribuição espacial



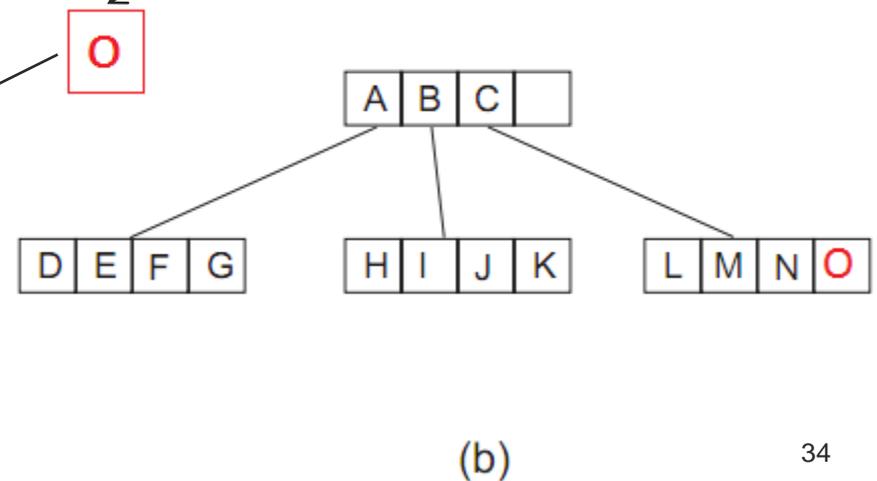
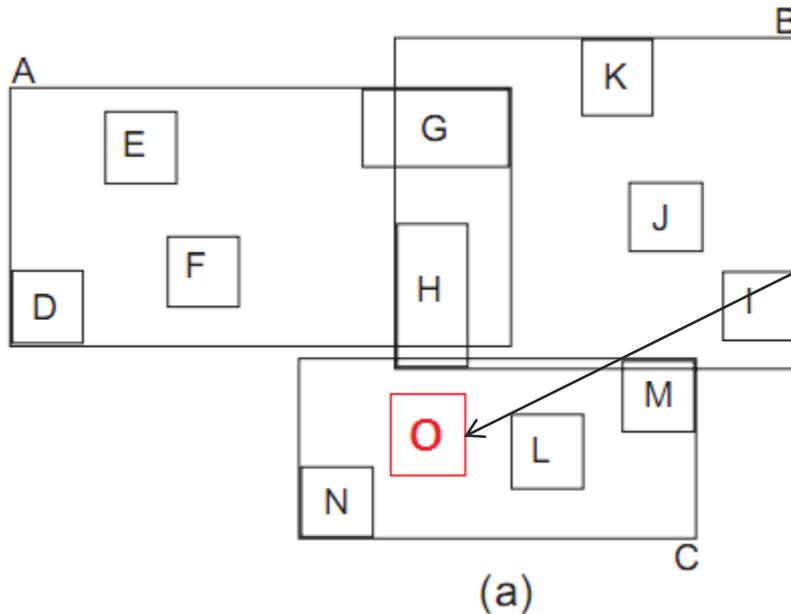
Estrutura lógica

Técnicas de indexação multidimensional

- R-Tree
 - Inserção



Vetor de característica



Medidas de Similaridade

- Distância Euclidiana

$$E(x, y) = \sqrt{\sum_{a=1}^n (x_a - y_a)^2}$$

- Euclidiana Normalizada

$$En(x, y) = \sqrt{\sum_{a=1}^n \left(\frac{|x_a - y_a|}{\max(a) - \min(a)} \right)^2}$$

- Manhattan (city-block)

$$D(x, y) = \sum_{a=1}^n |x_a - y_a|$$

- Chebychev

$$D(x, y) = \max_{a=1}^n |x_a - y_a|$$

- Camberra

$$D(x, y) = \sum_{a=1}^n \frac{|x_a - y_a|}{|x_a + y_a|}$$

Medidas de Similaridade

■ Distância de Hamming

$$H(x, y) = \sum_{a=1}^n h_a(x_a, y_a) \quad h_a(x_a, y_a) = \begin{cases} 1, & \text{se } x_a \neq y_a \\ 0, & \text{se } x_a = y_a \end{cases}$$

■ VDM – *Value Difference Metric*

- Semelhança entre as distribuições das classes

$$VDM(x, y) = \sqrt{\sum_{a=1}^n vdm_a(x_a, y_a)}$$

$$vdm_a(x, y) = \sum_{c=1}^C \left| \frac{N_{a,x,c}}{N_{a,x}} - \frac{N_{a,y,c}}{N_{a,y}} \right|^q = \sum_{c=1}^C |P_{a,x,c} - P_{a,y,c}|^q$$

[Avaliação da qualidade]

- Matriz de confusão;

	Exemplo Positivo	Exemplo Negativo
Classificado como Positivo	Verdadeiro Positivo	Falso Positivo
Classificado como Negativo	Falso Negativo	Verdadeiro Negativo

[Avaliação da qualidade]

- Taxa de verdadeiros positivos

$$\frac{VP}{VP + FN}$$

- Taxa de falsos positivos

$$\frac{FP}{FP + VN}$$

[Avaliação da qualidade]

- Revocação

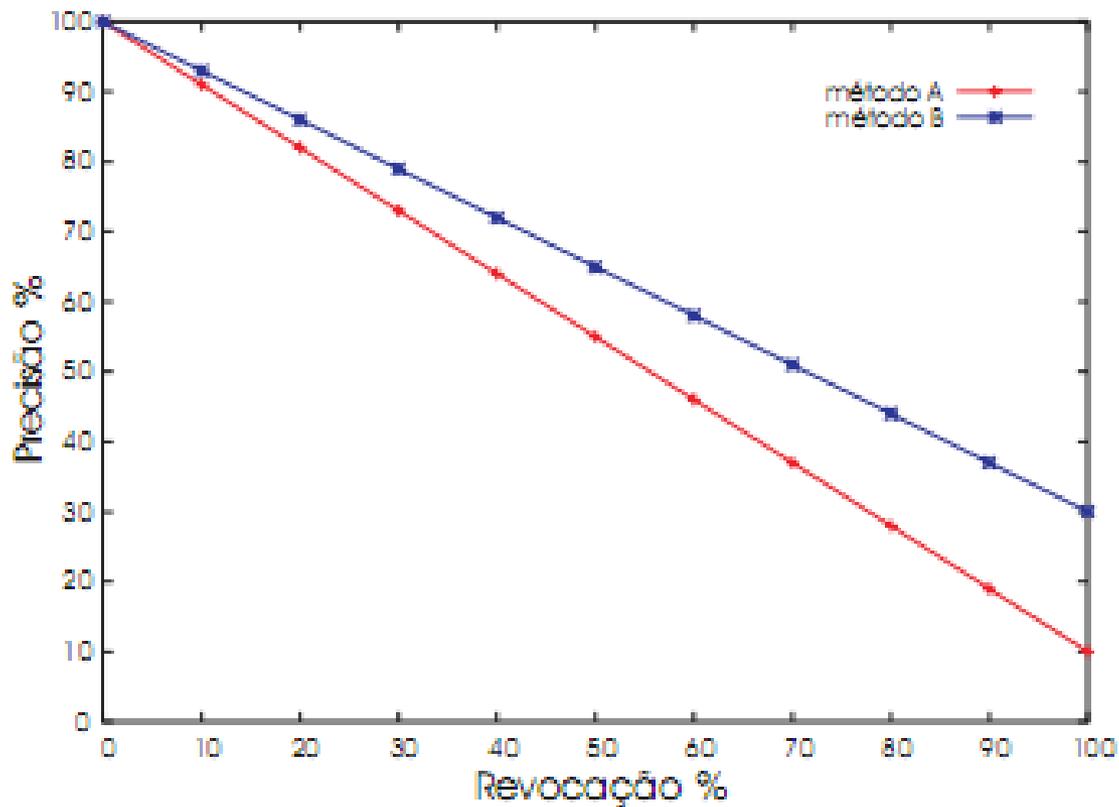
$$\frac{VP}{VP + FN}$$

- Precisão

$$\frac{TP}{TP + FP}$$

Avaliação da qualidade

■ Curva ROC



[Desafios]

- Semantic Gap;
- Grande volume de dados;
- Descoberta de novas relações e mineração de padrões;
- Novas interfaces e técnicas de visualização de informação para anotação;
- ...

Sistemas CBIR

- FIDS (*Flexible Image Database System*)
- QBIC (*Query By Image Content*)
- ALIPR (*Automatic Linguistic Indexing of Pictures - Real Time*)
- BIRAM (Base de Imagem Relacional de Algoritmo e Métricas)
- SIMPLicity (*Semantics-Sensitive Integrated Matching for Picture Libraries*)
- SQUID (*Shape Queries Using Image Databases*)
- Surfimage
- ADL (*Alexandria Digital Library*)
- CalPhotos
- ...

FIDS - *Flexible Image Database System*

[FIDS - *Flexible Image Database System*]

- FIDS permite ao usuário consultar o banco de dados com base em complexas combinações de medidas de distância pré-definidas.

FIDS - Flexible Image Database System

demo: Fids

Fids demo



Put In Cart

Check Out

◀ Random Go ZoomIn ▶ Get random images ...

distance measures loose ... strict

<input type="checkbox"/> ColorHistL_14x4x4	<input type="checkbox"/>	5	<input checked="" type="radio"/> And <input type="radio"/> Or <input type="radio"/> Sum
<input checked="" type="checkbox"/> ColorHist8x8x8	<input type="checkbox"/>	5	
<input type="checkbox"/> SobelEdgeHist	<input type="checkbox"/>	5	
<input type="checkbox"/> LBPHist	<input type="checkbox"/>	5	
<input type="checkbox"/> fleshiness	<input type="checkbox"/>	5	
<input type="checkbox"/> Wavelets	<input type="checkbox"/>	5	

A double click on an image means:

- Set query / Go
- Zoom in

Server Connected

FIDS - Flexible Image Database System

demo: Fids

Fids demo



Put In Cart

Check Out

Random Go ZoomIn Get random images ...

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<input type="checkbox"/> LBPHist	<input type="checkbox"/>	5	
<input type="checkbox"/> fleshiness	<input type="checkbox"/>	5	
<input type="checkbox"/> Wavelets	<input type="checkbox"/>	5	

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FIDS - Flexible Image Database System

demo: Fids

Fids demo

The screenshot displays the FIDS demo interface. At the top, there is a search bar containing the text "demo: Fids". Below the search bar, the title "Fids demo" is displayed in red. The main area shows a grid of six image search results. The first image in the top-left corner is highlighted with a red border. To the right of the grid is a vertical scroll bar and a "Put In Cart" button, which is also highlighted with a red border. Below the "Put In Cart" button is a "Check Out" button. At the bottom of the interface, there are navigation buttons: "Random", "Go", "ZoomIn", and "ZoomOut". To the right of these buttons, it says "Found 147 matches. Displaying 1 - 6". Below the navigation buttons is a section for "distance measures" with a "loose ... strict" toggle. The "loose" option is selected. The distance measures listed are: ColorHistL14x4x4 (unchecked), ColorHist8x8x8 (checked), SobelEdgeHist (unchecked), LBPHist (checked), fleshiness (unchecked), and Wavelets (unchecked). Each measure has a slider bar and a value of 5. To the right of the distance measures are radio buttons for "And", "Or", and "Sum", with "Sum" selected. A text box on the right side of the interface contains the text "A double click on an image means:" followed by radio buttons for "Set query / Go" (selected) and "Zoom in".

FIDS - Flexible Image Database System

demo: Fids

Fids demo

Found 147 matches. Displaying 1 - 6

distance measures loose ... strict

<input type="checkbox"/> ColorHistL14x4x4		5	<input type="radio"/> And
<input checked="" type="checkbox"/> ColorHist8x8x8		5	<input type="radio"/> Or
<input type="checkbox"/> SobelEdgeHist		5	<input checked="" type="radio"/> Sum
<input checked="" type="checkbox"/> LBPHist		5	
<input type="checkbox"/> fleshiness		5	
<input type="checkbox"/> Wavelets		5	

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FIDS - Flexible Image Database System

demo: Fids

Fids demo

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<input type="checkbox"/> ColorHistL14x4x4		5	<input type="radio"/> And
<input checked="" type="checkbox"/> ColorHist8x8x8		5	<input type="radio"/> Or
<input type="checkbox"/> SobelEdgeHist		5	<input checked="" type="radio"/> Sum
<input checked="" type="checkbox"/> LBPHist		5	
<input type="checkbox"/> fleshiness		5	
<input type="checkbox"/> Wavelets		5	

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distance measures	loose ... strict	
<input type="checkbox"/> ColorHistL14x4x4		5
<input checked="" type="checkbox"/> ColorHist8x8x8		5
<input type="checkbox"/> SobelEdgeHist		5
<input checked="" type="checkbox"/> LBPHist		5
<input type="checkbox"/> fleshiness		5
<input type="checkbox"/> Wavelets		5

Below the search criteria, there are three radio buttons for logical operations: "And", "Or", and "Sum". The "Sum" option is selected. To the right of these options, there is a box with the text "A double click on an image means:" and two radio buttons: "Set query / Go" (selected) and "Zoom in".

FIDS - Flexible Image Database System

demo: Fids

Fids demo

Found 147 matches. Displaying 1 - 6

distance measures loose ... strict

<input type="checkbox"/> ColorHistL14x4x4		5	<input type="radio"/> And
<input checked="" type="checkbox"/> ColorHist8x8x8		5	<input type="radio"/> Or
<input type="checkbox"/> SobelEdgeHist		5	<input checked="" type="radio"/> Sum
<input checked="" type="checkbox"/> LBPHist		5	
<input type="checkbox"/> fleshiness		5	
<input type="checkbox"/> Wavelets		5	

A double click on an image means:

- Set query / Go
- Zoom in

FIDS - Flexible Image Database System

demo: Fids

Fids demo

The screenshot displays the FIDS demo interface. At the top, there is a search bar containing the text "demo: Fids". Below the search bar, the title "Fids demo" is displayed in red. The main area shows a grid of six image search results, with the first image (a pink flowering tree) highlighted by a red border. To the right of the grid is a vertical image viewer showing the selected image, with "Put In Cart" and "Check Out" buttons below it. At the bottom, there is a navigation bar with "Random", "Go", and "ZoomIn" buttons, followed by the text "Found 147 matches. Displaying 1 - 6". Below the navigation bar is a control panel for distance measures, with a red box highlighting the "ColorHistL14x4x4", "ColorHist8x8x8", "LBPHist", and "Wavelets" options. To the right of the distance measures are radio buttons for "And", "Or", and "Sum", with "Sum" selected. A separate box on the right contains the text "A double click on an image means:" and radio buttons for "Set query / Go" (selected) and "Zoom in".

distance measures loose ... strict

- ColorHistL14x4x4
- ColorHist8x8x8
- SobelEdgeHist
- LBPHist
- fleshiness
- Wavelets

And
 Or
 Sum

A double click on an image means:
 Set query / Go
 Zoom in

FIDS - Flexible Image Database System

demo: Fids

Fids demo

The screenshot displays the FIDS demo interface. At the top, a browser window shows the URL 'demo: Fids'. Below this, the title 'Fids demo' is displayed in red. The main area features a grid of six search results for a query image (a cherry blossom tree). The first result in the top-left is highlighted with a red border. To the right of the grid is a larger view of the selected image, with 'Put In Cart' and 'Check Out' buttons below it. At the bottom, a control bar includes 'Random', 'Go', 'ZoomIn', and 'ZoomOut' buttons, along with the text 'Found 147 matches. Displaying 1 - 6'. Below the control bar is a list of distance measures with checkboxes: 'ColorHistL14x4x4', 'ColorHist8x8x8' (checked), 'SobelEdgeHist', 'LBPHist' (checked), 'fleshiness', and 'Wavelets'. To the right of these measures is a 'loose ... strict' slider with five tick marks, each labeled '5'. Further right are radio buttons for 'And', 'Or', and 'Sum' (selected). On the far right, a box contains the text 'A double click on an image means:' followed by radio buttons for 'Set query / Go' (selected) and 'Zoom in'.

FIDS - Flexible Image Database System

demo: Fids

Fids demo

The interface displays a grid of six image search results. The top-left image is highlighted with a red border. To the right, a larger view of the same image is shown with navigation arrows and a 'Put In Cart' button. Below the grid, a status bar indicates 'Found 147 matches. Displaying 1 - 6' and includes 'Random', 'Go', and 'ZoomIn' buttons.

distance measures loose ... strict

<input type="checkbox"/> ColorHistL14x4x4		5
<input checked="" type="checkbox"/> ColorHist8x8x8		5
<input type="checkbox"/> SobelEdgeHist		5
<input checked="" type="checkbox"/> LBPHist		5
<input type="checkbox"/> fleshiness		5
<input type="checkbox"/> Wavelets		5

And
 Or
 Sum

A double click on an image means:
 Set query / Go
 Zoom in

QBIC - *Query By Image Content*

[QBIC - *Query By Image Content*]

- QBIC permite consultas baseadas em imagens de exemplo, esboço construído pelo usuário e/ou padrões de cor e textura selecionados.

QBIC - Query By Image Content

QUICK SEARCH

BROWSE +

- QBIC SEARCHES +
- COLOUR SEARCH -
- LAYOUT SEARCH -
- ADVANCED SEARCH +

QBIC COLOUR SEARCH

1. Use your mouse to select a colour from the palette.

2. Click the arrow button to add the colour to the bucket.

3. Slide the triangular handles on the bucket to adjust the percentage of this colour.

4. You may repeat this process until the bucket is full. When you are ready, click Search.

You may also use the Colour Mixer to adjust RGB (red, green, blue) values to use in your search.

Click Delete to remove a colour from the bucket. Click Clear All to empty the bucket.

QBIC - Query By Image Content

The State Hermitage Museum: Digita...

QUICK SEARCH

BROWSE +

QBIC SEARCHES +

COLOUR SEARCH -

LAYOUT SEARCH -

ADVANCED SEARCH +

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QBIC - Query By Image Content

The State Hermitage Museum: Digita...

QUICK SEARCH

go

BROWSE +

QBIC SEARCHES +

COLOUR SEARCH -

LAYOUT SEARCH -

ADVANCED SEARCH +

QBIC COLOUR SEARCH

1. Use your mouse to select a colour from the palette.

2. Click the arrow button to add the colour to the bucket.

3. Slide the triangular handles on the bucket to adjust the percentage of this colour.

4. You may repeat this process until the bucket is full. When you are ready, click Search.

You may also use the Colour Mixer to adjust RGB (red, green, blue) values to use in your search.

Click Delete to remove a colour from the bucket. Click Clear All to empty the bucket.

help demo

QBIC - Query By Image Content

QUICK SEARCH

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- QBIC SEARCHES ▾
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- LAYOUT SEARCH -
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SEARCH RESULTS

1) [Boats at Saintes-Maries](#)

 Gogh, Vincent van 1888

2) [Stained Glass Panel: Antichrist Making a Fiery Storm \(10a\)](#)

 UNKNOWN
Late 14th century
(?)

3) [Portrait of Mikhail N. Ryleev \(1771-1831\) \(1st\)](#)

 Dawe, George 1824

4) [Peonies](#)

 Girieud, Pierre Paul 1906

5) [Portrait of Yefim I. Chaplits \(1768-1825\)](#)

 Dawe, George
No later than 1825

6) [Portrait of Pyotr A. Kosen \(1778-1853\)](#)

 Dawe, George 1823

7) [Portrait of Ivan L. Shakhovskoy \(1776-1860\)](#)



8) [Portrait of Ivan I. Palitsyn \(1763-1814\)](#)



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flower thing bart holly - similar »



natural cloud landscape winter snow mountain
alps europe - similar »



elephant - similar »

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Exploratory Features: **ACQUINE**- Rate Your Photos Aesthetically by Computer **NEW** <<<<<<

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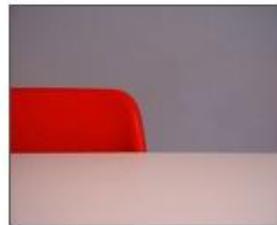
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animal horse horses - similar »



red - similar »



tokyo bravo sadness nippon union happiness joy - similar »

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| <input type="checkbox"/> food | <input type="checkbox"/> indoor | <input checked="" type="checkbox"/> plant | <input type="checkbox"/> tulip | <input type="checkbox"/> dessert |
| <input type="checkbox"/> life | <input type="checkbox"/> decoration | <input type="checkbox"/> texture | <input type="checkbox"/> fruit | <input type="checkbox"/> door |

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- indoor
- balloon
- landscape
- people
- food
- dining
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flower

search

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Visually similar pictures. page: 1/

The image displays a grid of 15 visually similar flower images. Each image is accompanied by a small icon and the text 'Related / Similar' below it. The images include various types of flowers such as purple crocuses, purple orchids, purple daisies, pink flowers, and a bee on a purple flower.

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Related pictures. sigma florida macro flower... page: 1/11

Each image in the grid is accompanied by a small icon and the text "Related / Similar". The "Related" text in the second image of the first row is highlighted with a red box.

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Related pictures: **odonata dragonfly sigma insect florida macro...** page: 1/10



The image displays a grid of 15 dragonfly photographs arranged in three rows of five. Each photograph is accompanied by a small circular icon containing a magnifying glass and the text "/ Related / Similar". The dragonflies shown are of various species and colors, including purple, green, blue, brown, and orange, in various poses and settings.

page: 1 2 3 4 5 6 7 8 9 10

BIRAM - Base de Imagem Relacional de Algoritmo e Métricas

BIRAM - Base de Imagem Relacional de Algoritmo e Métricas

- Protótipo desenvolvido em Java, que permite a utilização de diferentes algoritmos para a busca e recuperação de imagens por conteúdo.

BIRAM - Base de Imagem Relacional de Algoritmo e Métricas

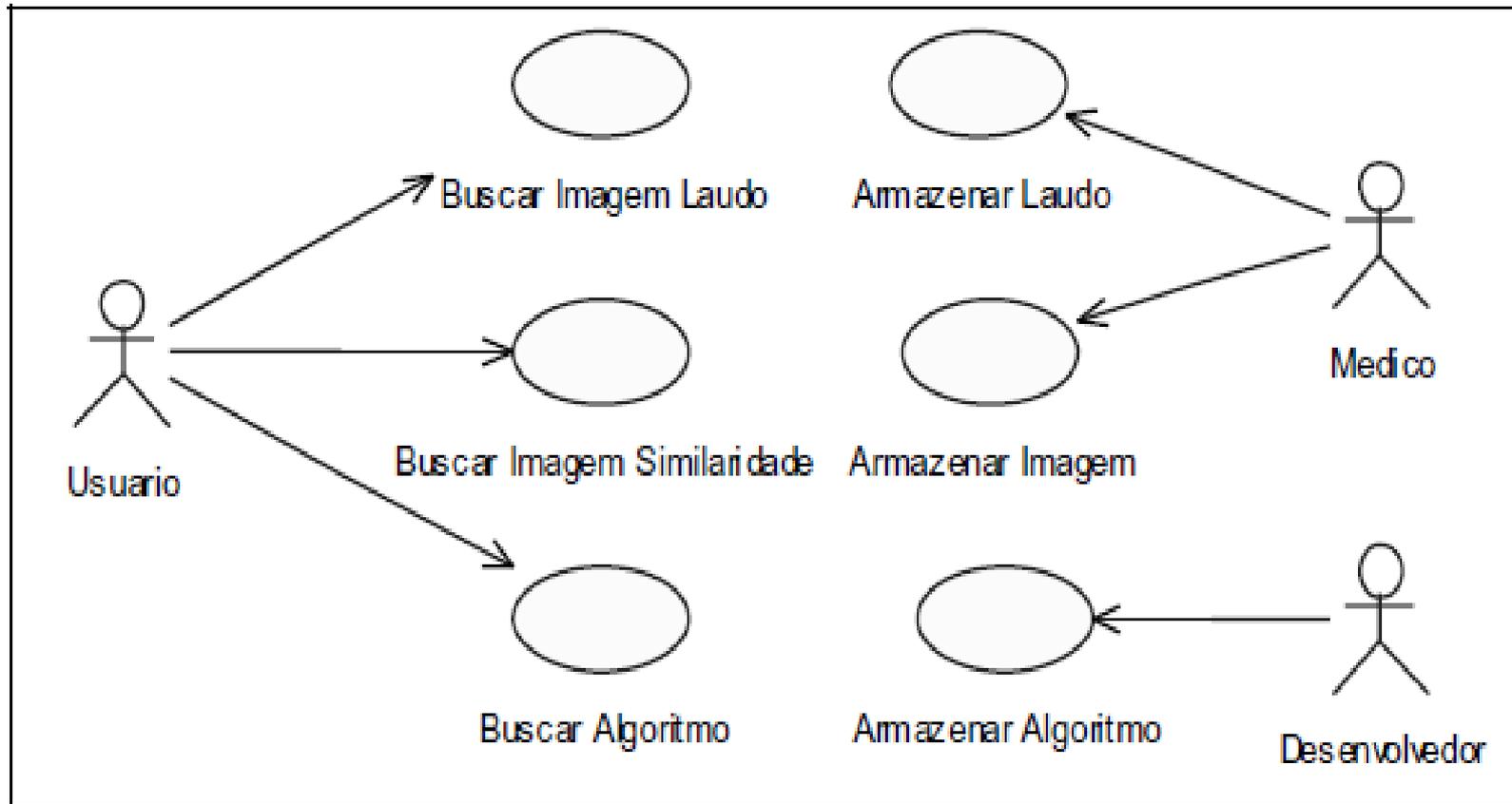


Figura 1 – Casos de uso do BIRAM

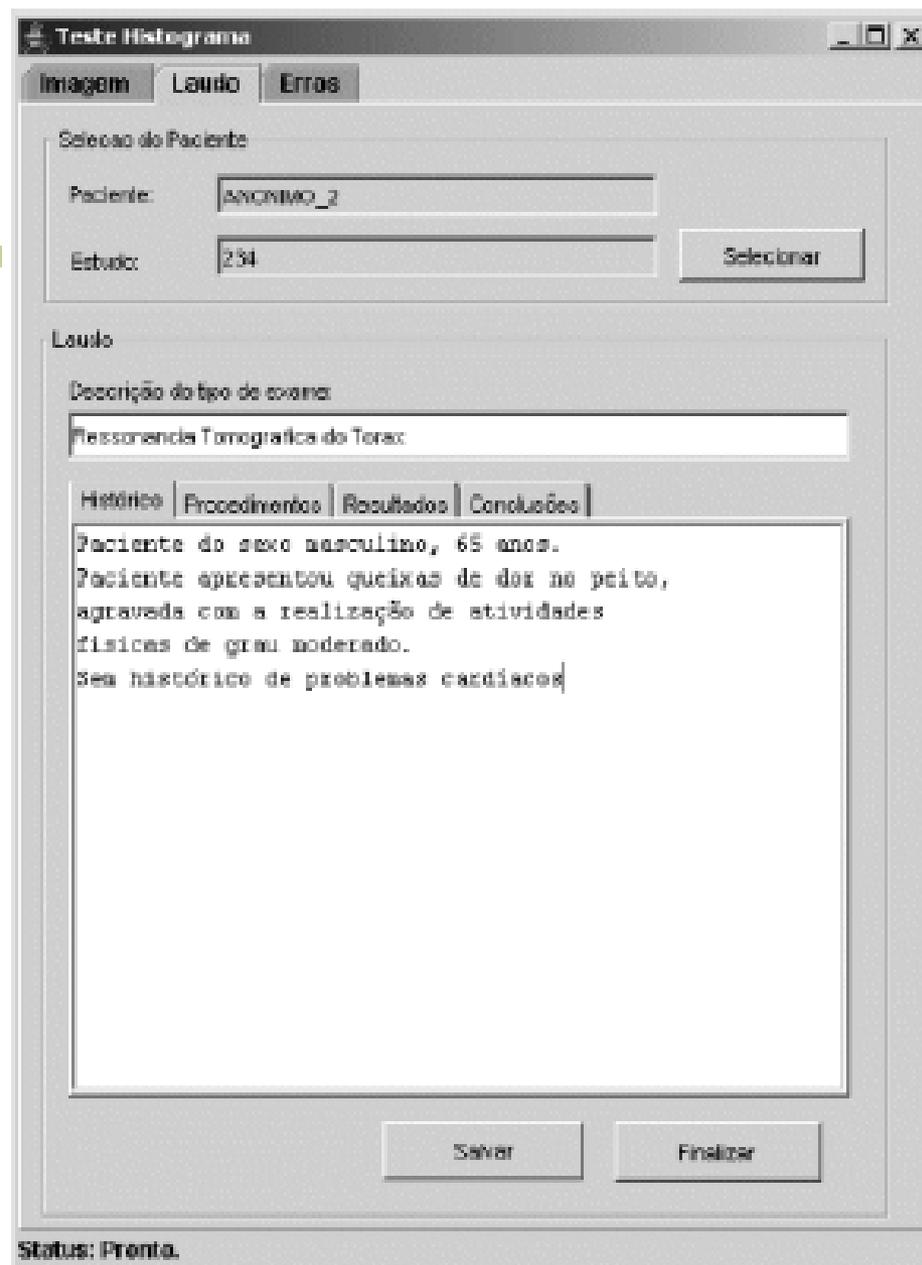


Figura 4 – Visualização de laudos



Figura 5 – Atribuição de uma conclusão ao laudo

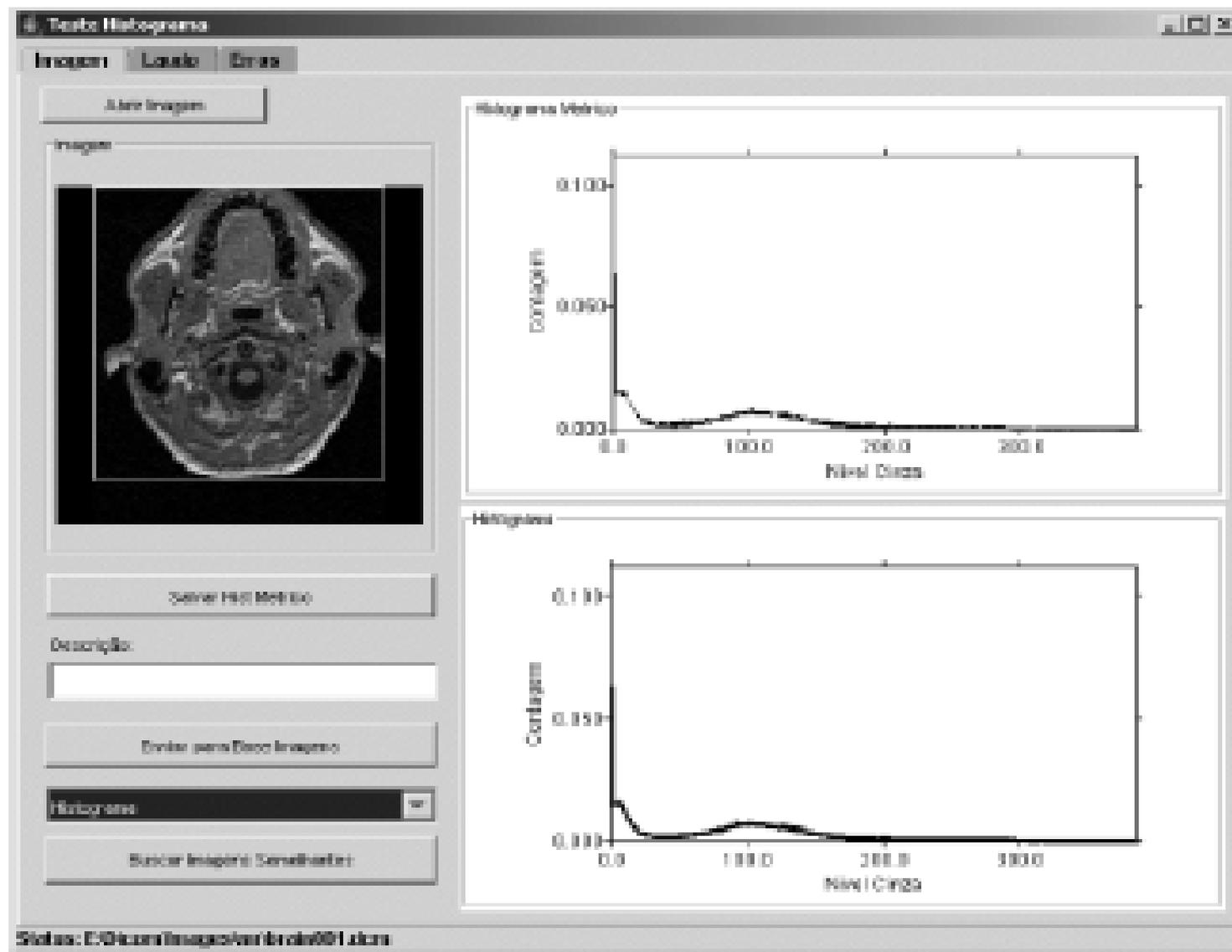


Figura 6 – Tela de busca de imagens semelhantes



Figura 7 – Resultado de pesquisa utilizando histograma métrico

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- ALIPR: <http://alipr.com/>



Indexação e Recuperação de Imagens por Conteúdo

Perguntas?