

Detecção automática de cabeças de baleias do gênero *Eubalaena* em imagens aéreas



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Projeto de Conclusão de Disciplina
Processamento Digital de Imagens
UNESP, Sorocaba – 2015

Introdução

- Gênero *Eubalaena* (baleias-francas)
 - Ameaçadas de extinção
 - Menos de 500 indivíduos
 - Dentre as três espécies
 - *E. glacialis*,
 - *E. japonica*
 - *E. australis*
 - *E. japonica* em estado crítico
(< 50 indivíduos)

Introdução

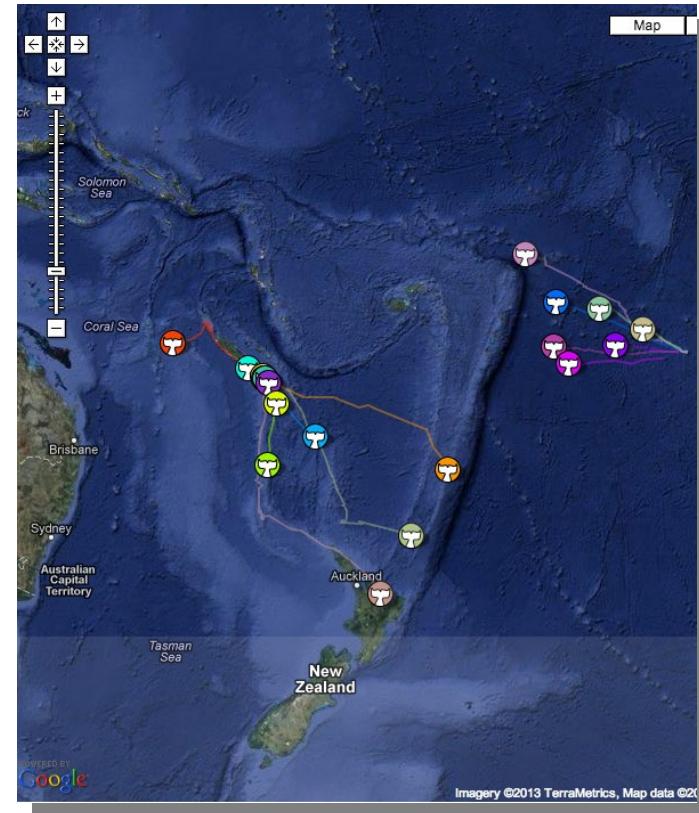
- Causas

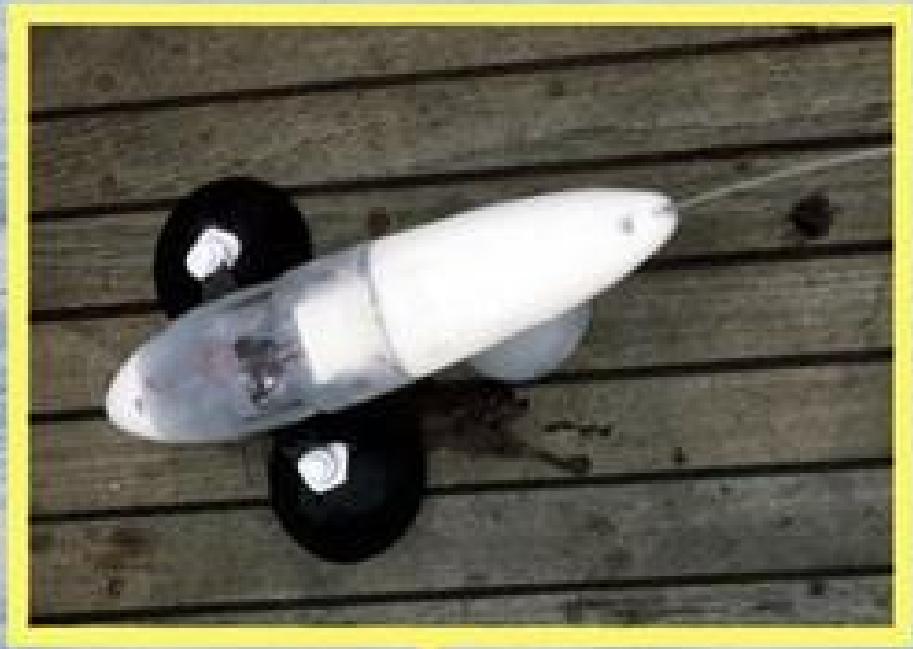
- Caça (alimentação, produção de óleos)
- Colisões com navios-cargueiros
- Rede de pescas



Introdução

- Programas de proteção dependem de
 - Catalogação
 - Rastreamento
 - Acompanhamento



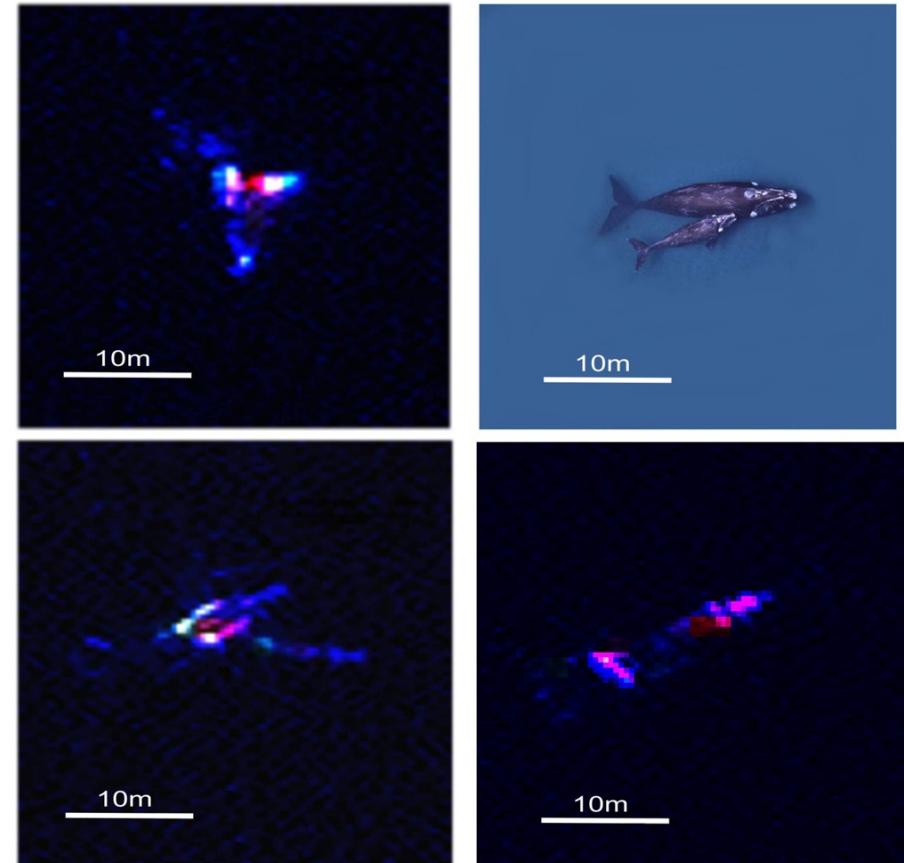
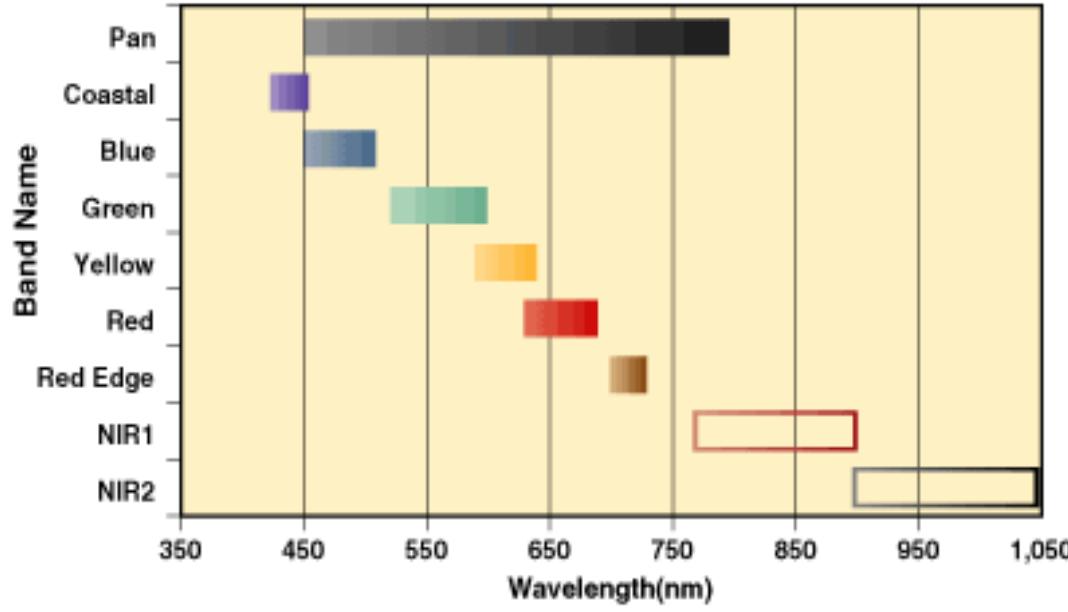


Fonte: <http://ocean.si.edu/north-atlantic-right-whale>

Introdução

- Rastreamento por satélite

- WorldView2 (resolução: 0,52 m)
- WorldView3 (resolução: 0,31 m)

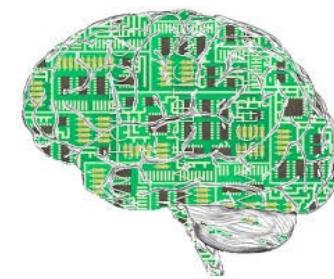
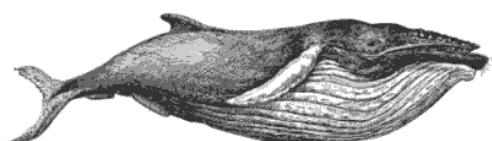


Introdução

- Problemas da identificação individual

- poucos oceanógrafos capazes
- trabalho minucioso e exaustivo
- tempo de espera entre avistamento e atualização do acervo

Solução: Aprendizado de Máquina



Introdução

Plataforma Kaggle

- <http://www.kaggle.com>
- Competições abordando problemas que devem ser resolvidos através de algoritmos de aprendizado de máquina.

The screenshot shows the Kaggle homepage. At the top, there is a navigation bar with links for Host, Competitions, Scripts, Jobs, Community, Sign up, and Login. Below the navigation bar, there is a welcome message: "Welcome to Kaggle's data science competitions." It also features links for "New to Data Science?", "Tutorials on the Titanic competition", and "Want to learn from other's code? Kaggle's top rated scripts". On the right side, there are four main sections: "Download" (with a trophy icon), "Build" (with a gear and chart icon), and "Submit" (with an upload icon). Below these sections, there is a brief description of each: "Choose a competition & download the training data.", "Build a model using whatever methods and tools you prefer.", and "Upload your predictions. Kaggle scores your solution and shows your score on the leaderboard.". At the bottom, there is a grid of "Active Competitions". The first column contains a "All Competitions" button and a "Deloitte." competition card. The second column contains a "The Allen AI Science Challenge" competition card. The third column contains a "The Winton Stock Market Challenge" competition card. The fourth column contains a "Rossmann Store Sales" competition card. Each competition card includes the competition name, a brief description, and a summary of participants and rewards.

Active Competitions		Active Competitions	
All Competitions		Western Australia Rental Prices  Predict rental prices for properties across Western Australia 12 days 61 teams \$100,000	
		The Allen AI Science Challenge Is your model smarter than an 8th grader? 2 months 357 teams \$80,000	
		The Winton Stock Market Challenge Join a multi-disciplinary team of research scientists 2 months 451 teams \$50,000	
		Rossmann Store Sales Forecast sales using store, promotion, and competitor data 26 days 2635 teams 1631 scripts \$35,000	

Introdução



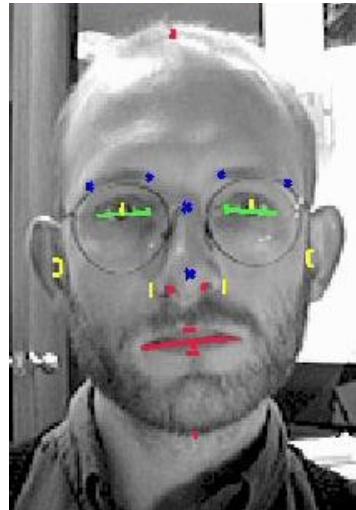
New England
Aquarium



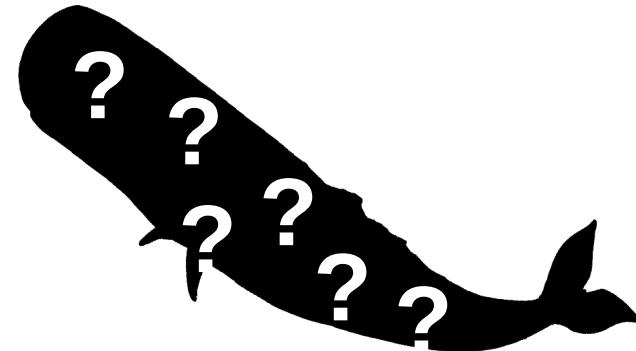
- Competição: *Right Whale Recognition*
 - Identificar corretamente cada uma das 500 baleias nas fotos fornecidas
 - Fornecer medida de confiança no reconhecimento
 - 8 gigabytes de material de treino

Introdução

- Reconhecimento de pessoas



baleias



- Regiões de interesse bem estudadas
- Algoritmos prontos e otimizados

- Regiões de interesse não conhecidas
- Algoritmos a fazer

Introdução

- Dificuldades no reconhecimento entre baleias
 - Orientação muda em cada foto
 - Diferentes ângulos fotografados
 - Movimento na água
 - Parcialmente submersas
 - Assunto pouco estudado
 - Exige interação entre programadores e biólogos



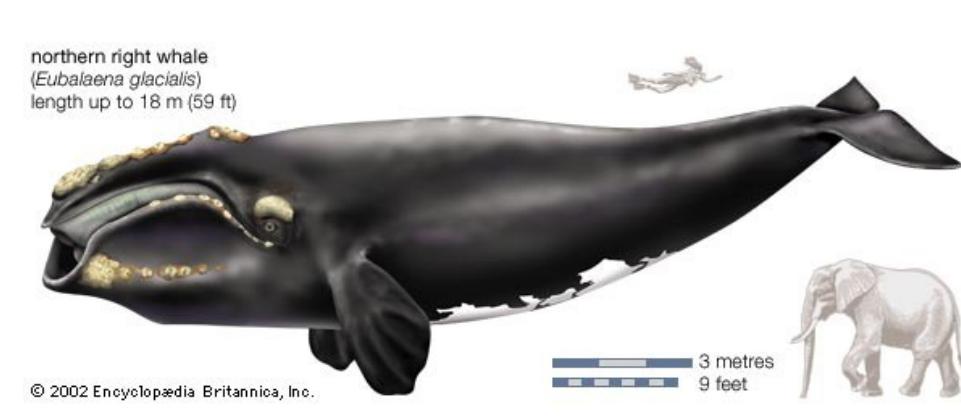




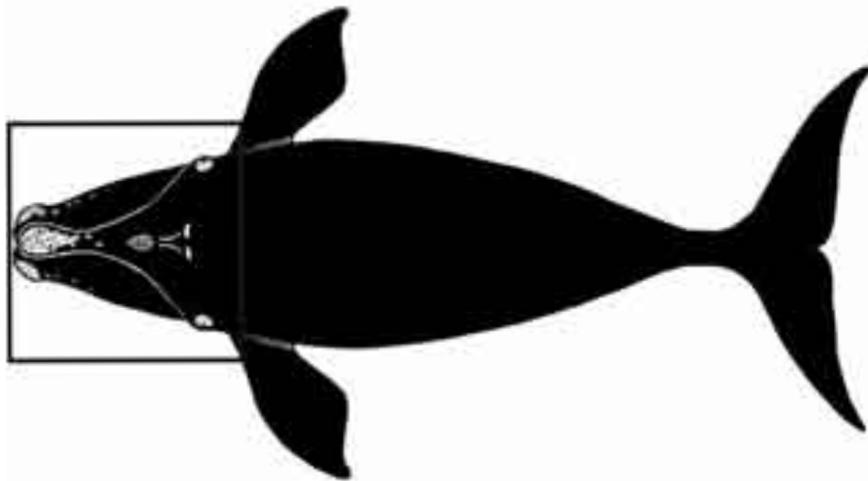


Introdução

- Características da baleia-franca



Peso: 18 toneladas
Comprimento: 30 metros



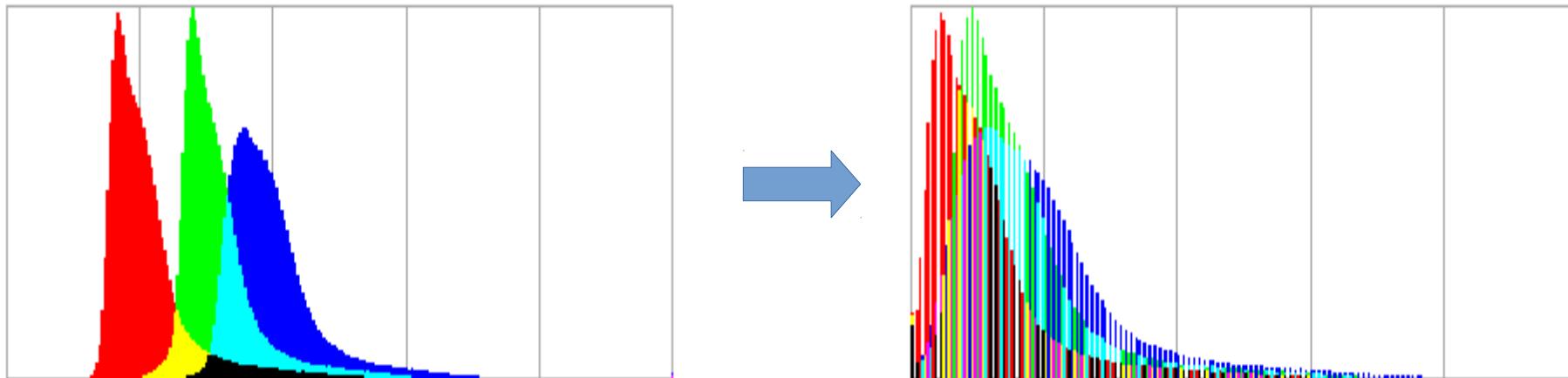
Objetivo

Sendo a fisionomia da cabeça a característica mais distinta do indivíduo, implementar um programa que busque e reconheça cabeças de baleias, independente da iluminação, matiz, tamanho, rotação e posição do animal na imagem.

Metodologia

1) Correção do balanço de branco

- “Esticar” o histograma em cada canal (R, G, B) separadamente



Metodologia

1) Correção do balanço de branco



Metodologia

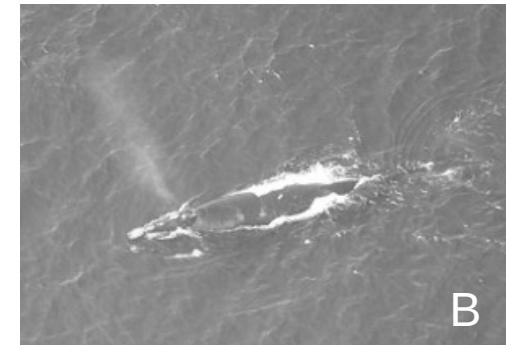
- 2) Decomposição em canais H, S e V



R



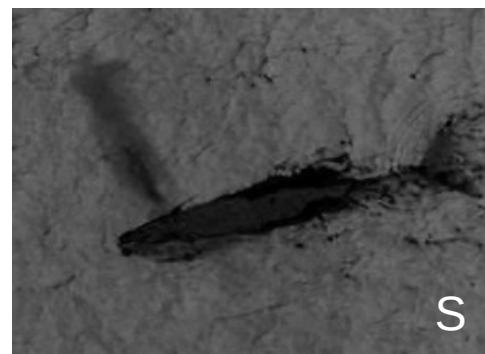
G



B



H



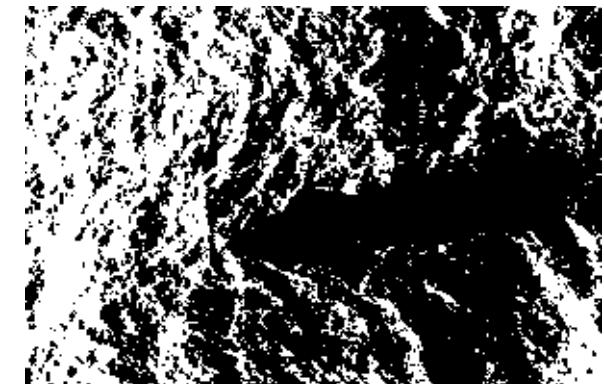
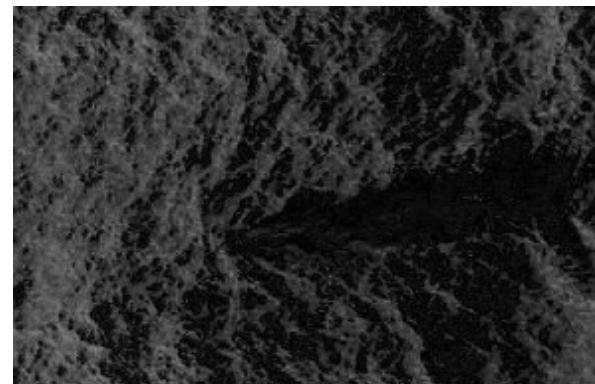
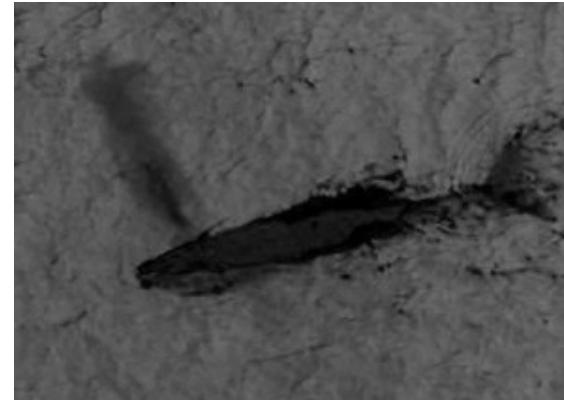
S



V

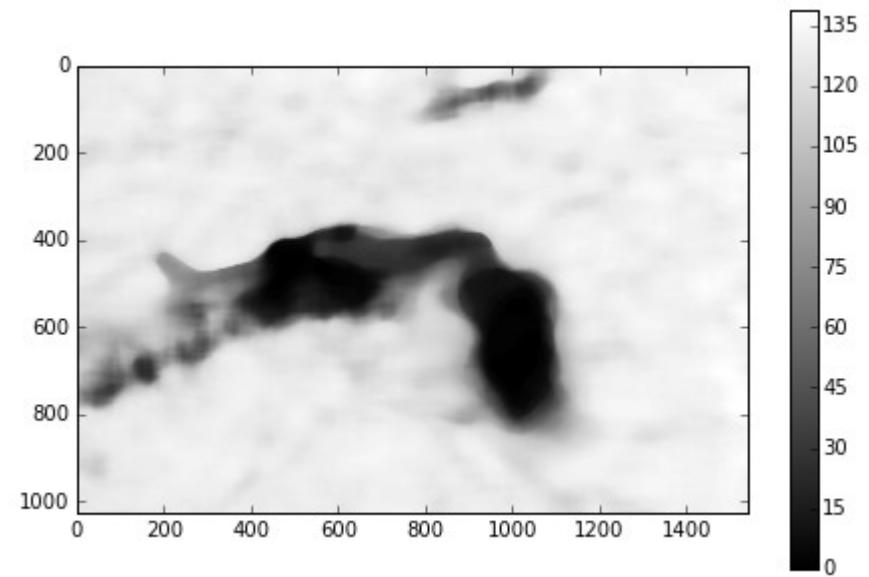
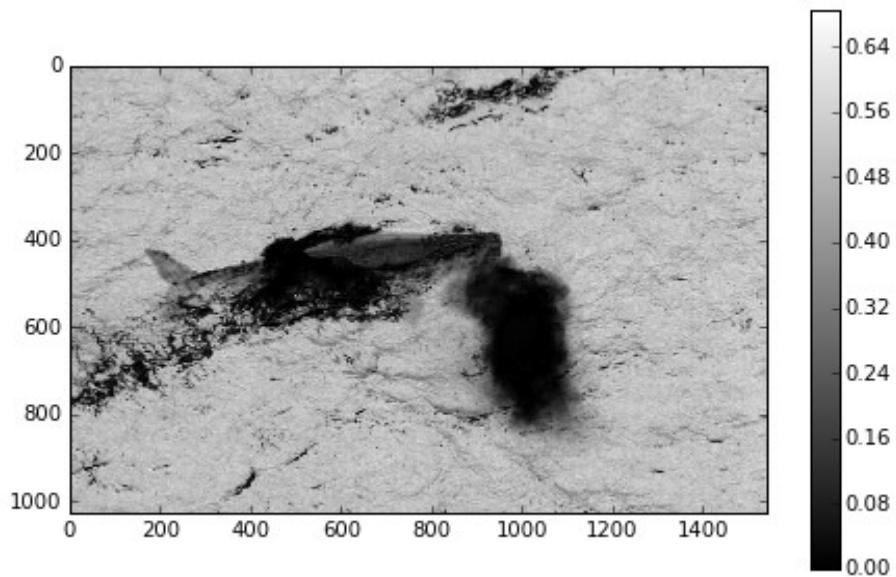
Pergunta: Seria possível parar por aqui e fazer a limiarização de um dos canais?

Metodología



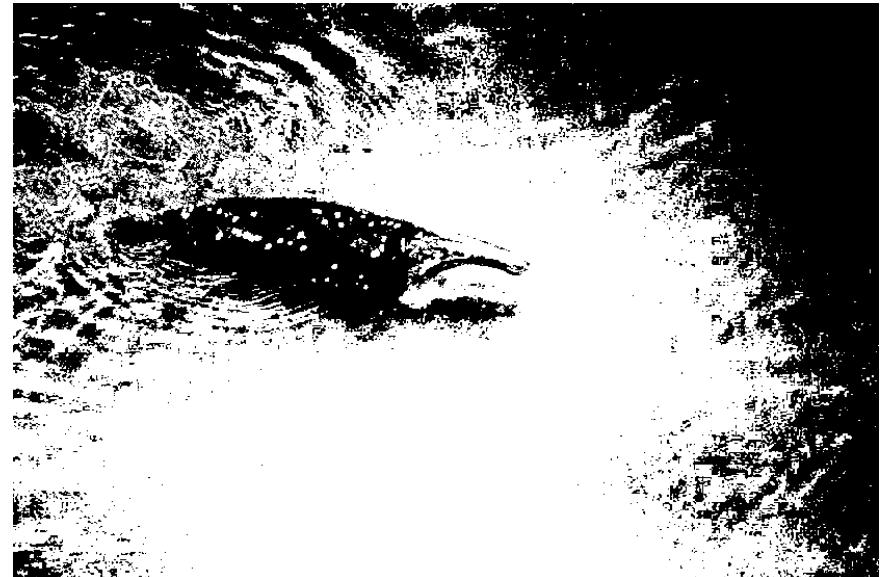
3) Remoção de reflexos e sombras

- Filtro mediano



Metodologia

4) Correção de vinheta



Metodologia

4) Correção de vinheta

Canal V

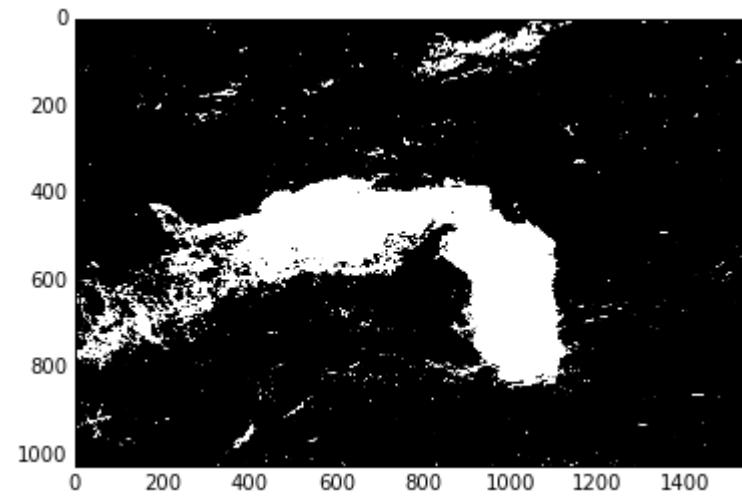
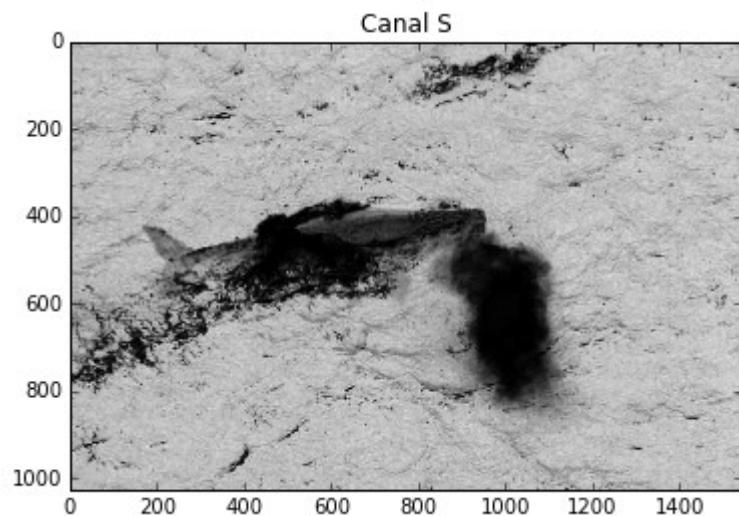


Canal V \times máscara gaussiana



Metodologia

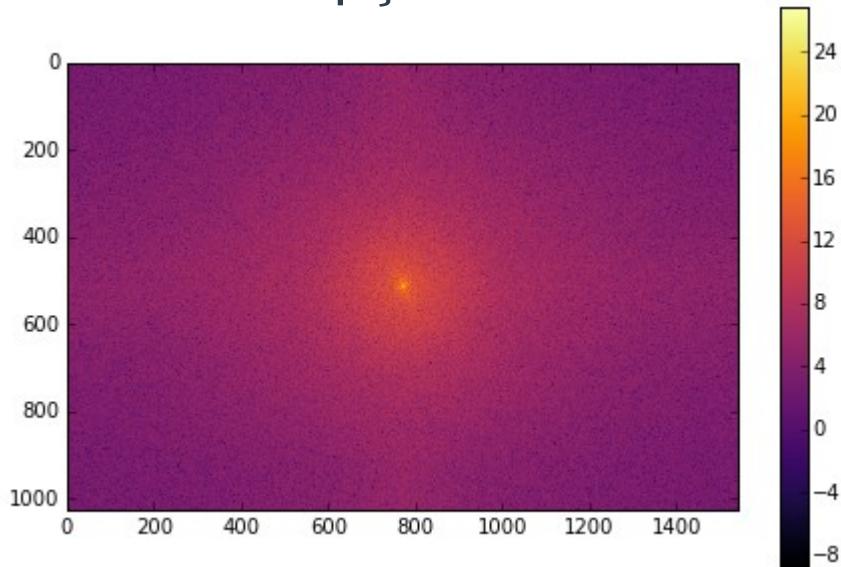
5) Escolha do canal menos conturbado



Metodologia

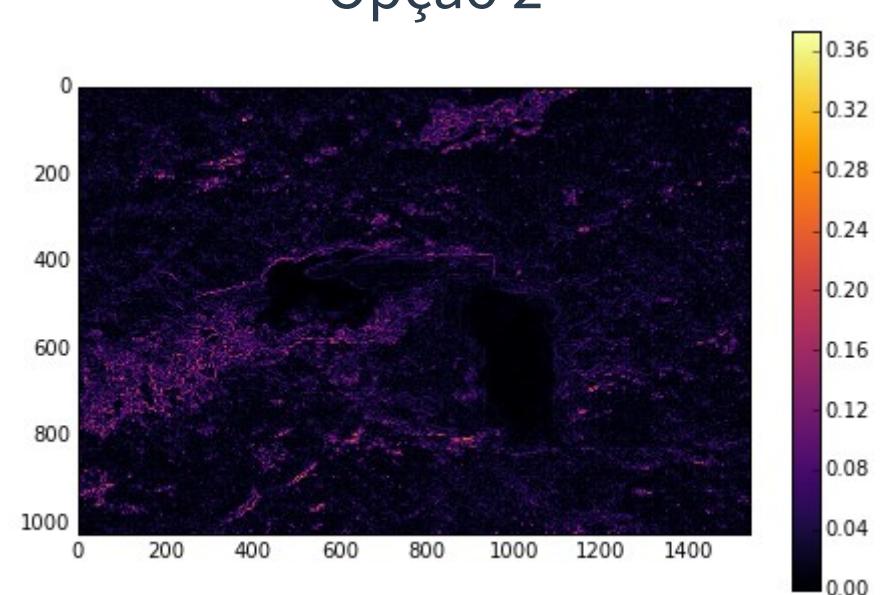
5) Escolha do canal menos conturbado

Opção 1



Transformada de Fourier

Opção 2

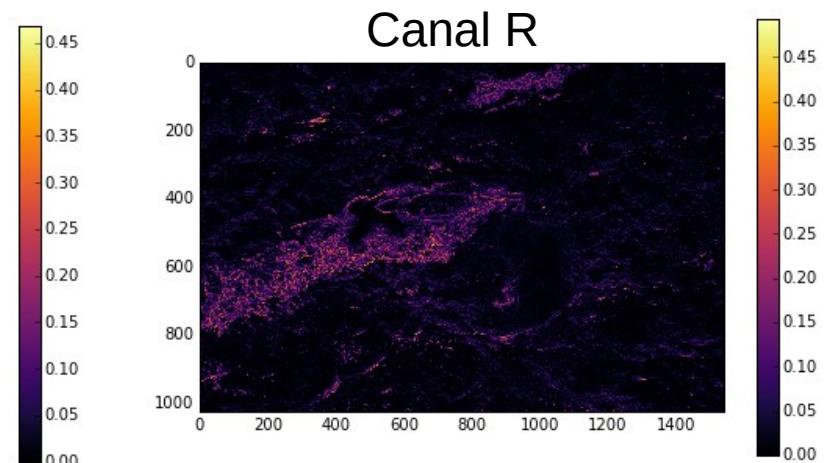
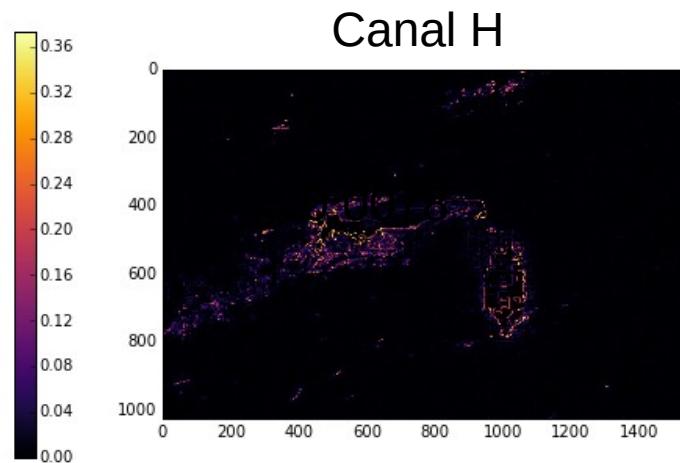
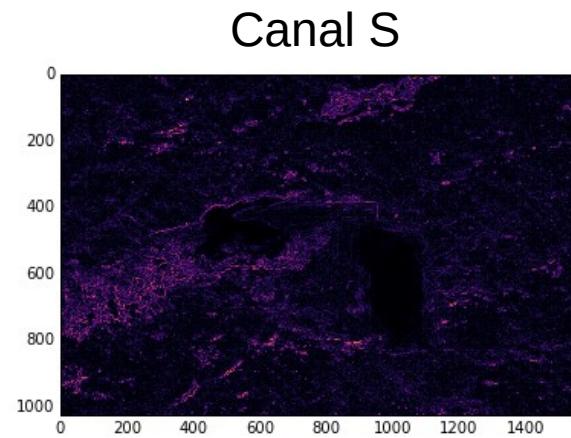


Sobel

Metodologia

5) Escolha do canal menos conturbado

- Candidatos: H, S e R



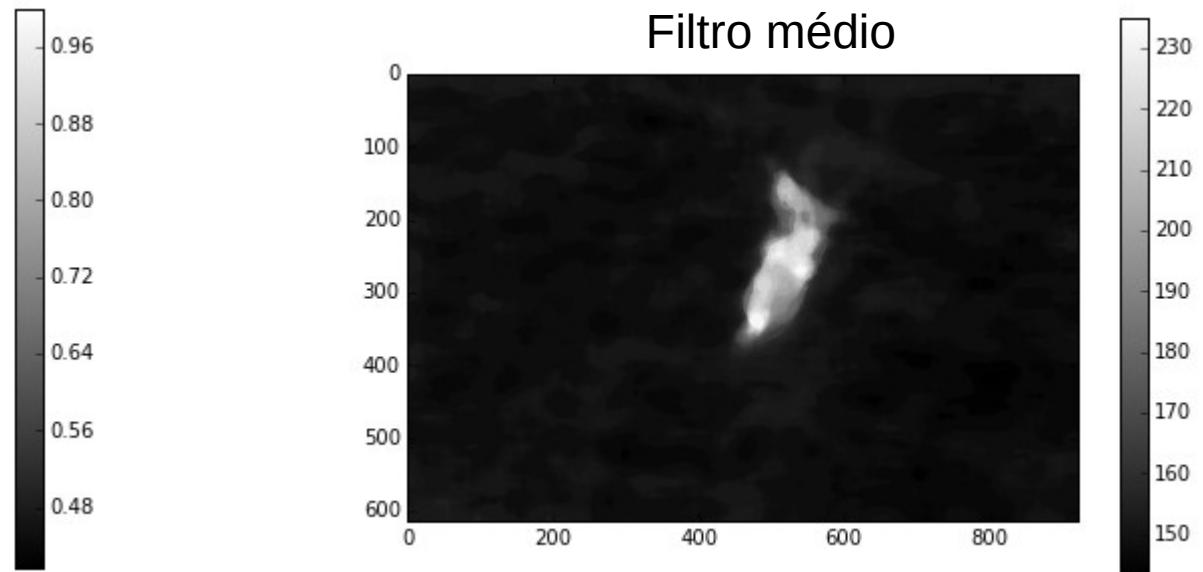
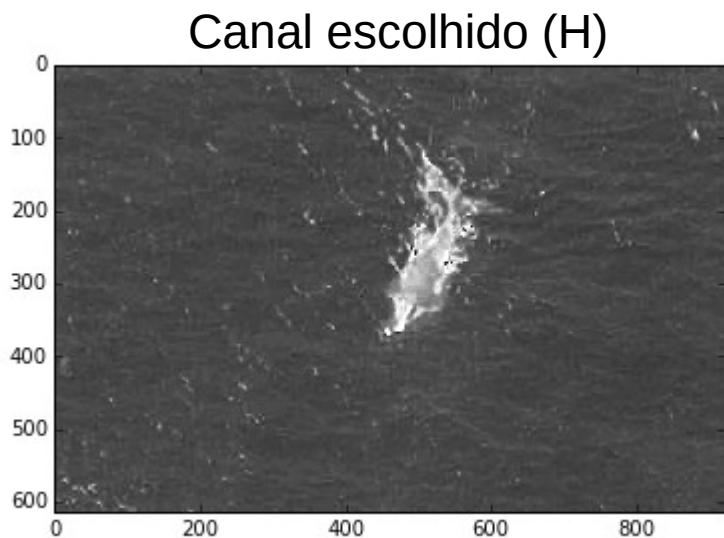
$$\Sigma = 0.0236$$

$$\Sigma = 0.0078$$

$$\Sigma = 0.0262$$

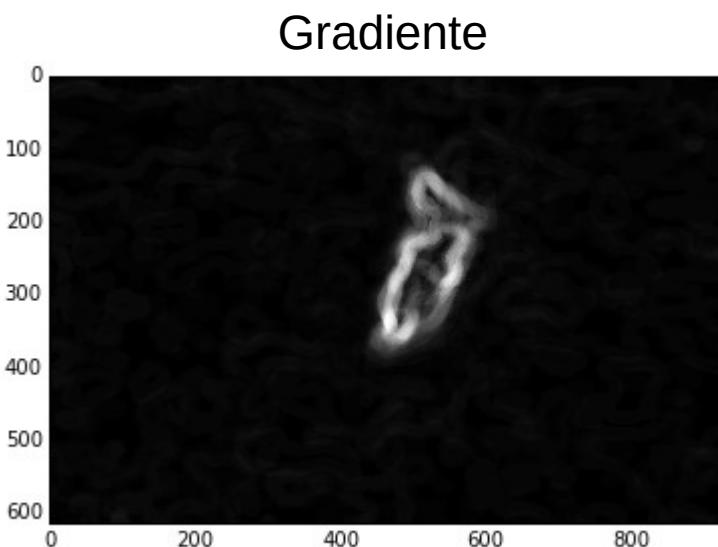
Metodologia

6) Bordas e segmentação



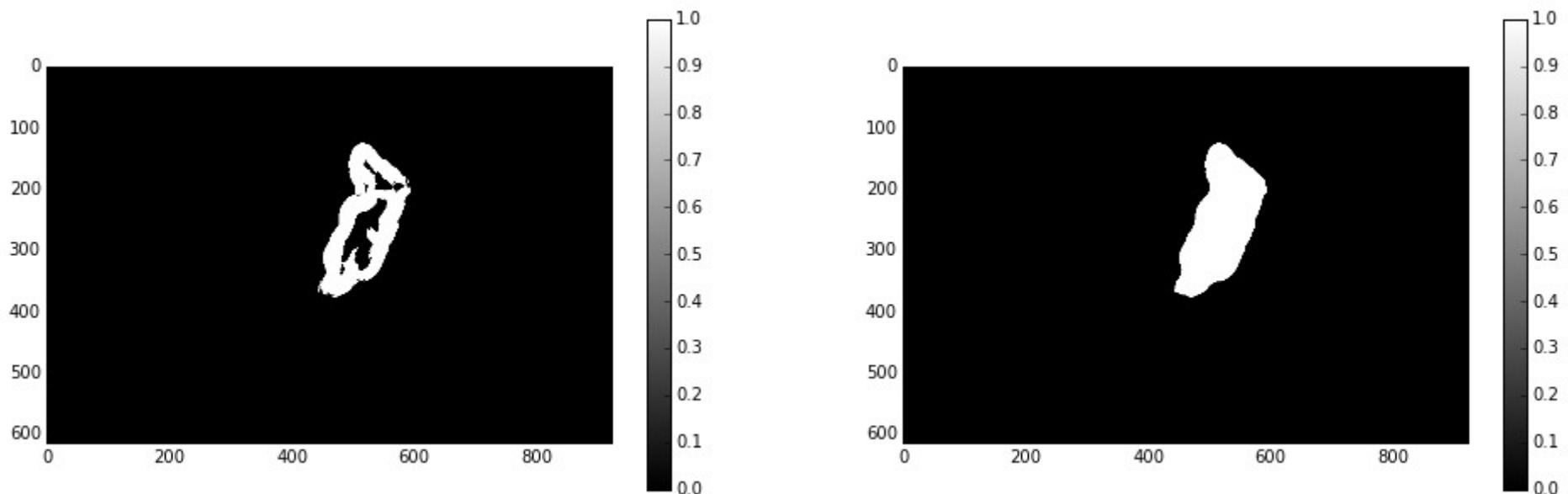
Metodologia

6) Bordas e segmentação



Metodologia

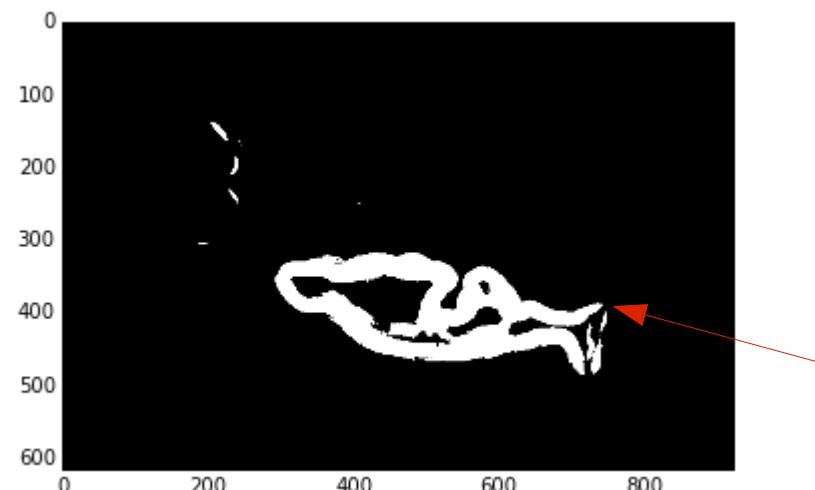
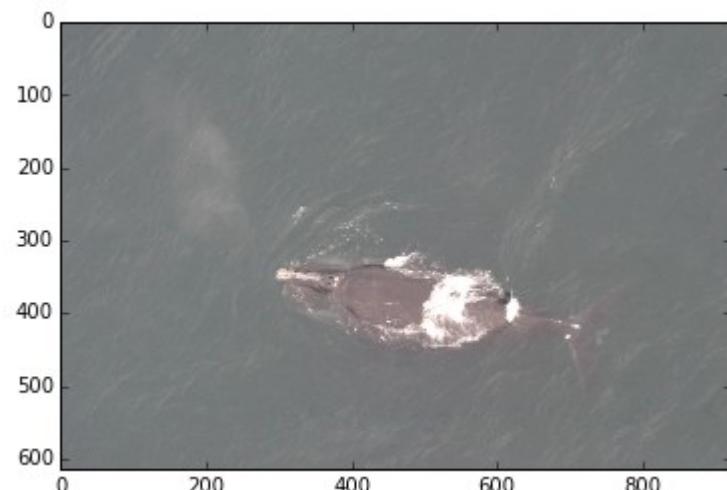
7) Fechamento de intervalos e preenchimento das formas



- **Método de fechamento:** dilatação seguida de erosão
- Funciona na maioria dos casos

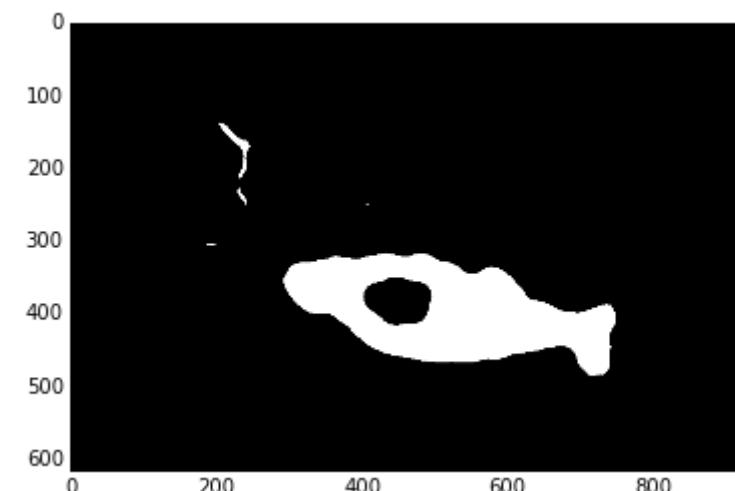
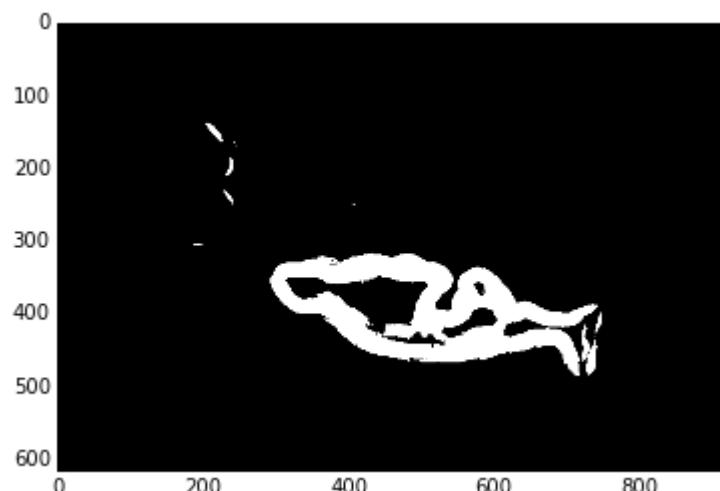
Metodologia

7) Fechamento de intervalos e preenchimento das formas



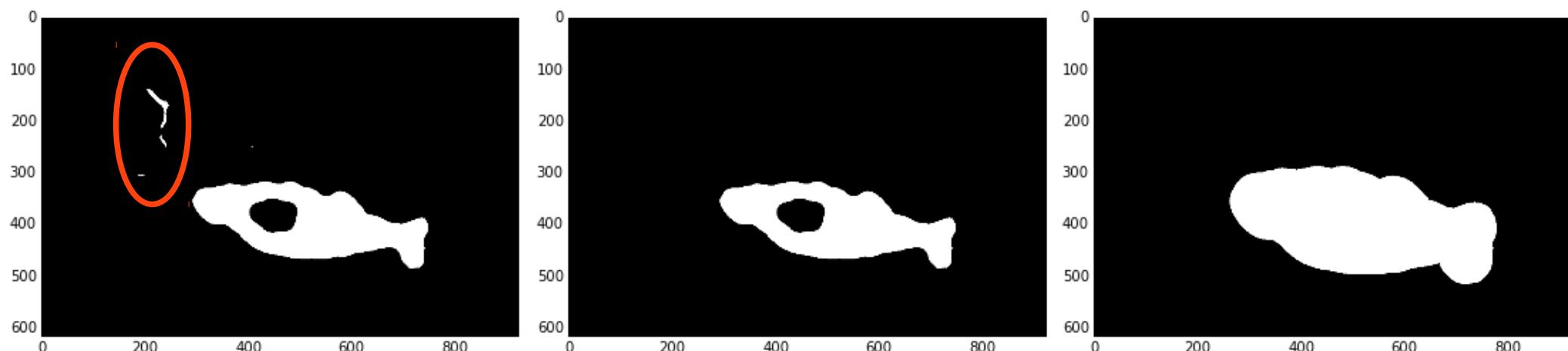
Metodologia

7) Fechamento de intervalos e preenchimento das formas



Metodologia

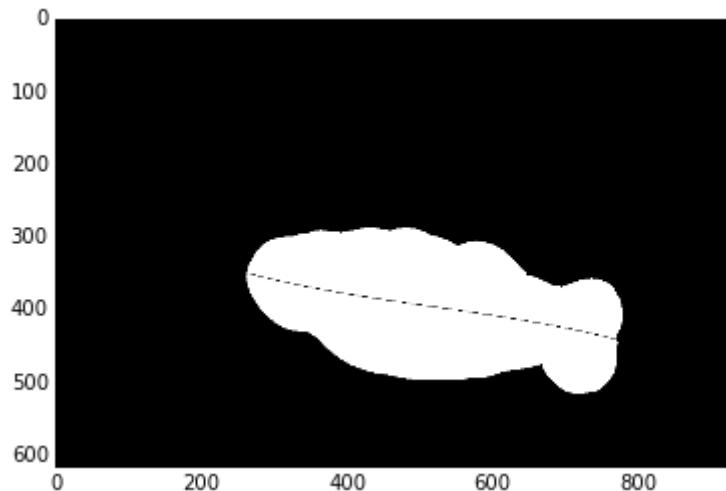
7) Fechamento de intervalos e preenchimento das formas



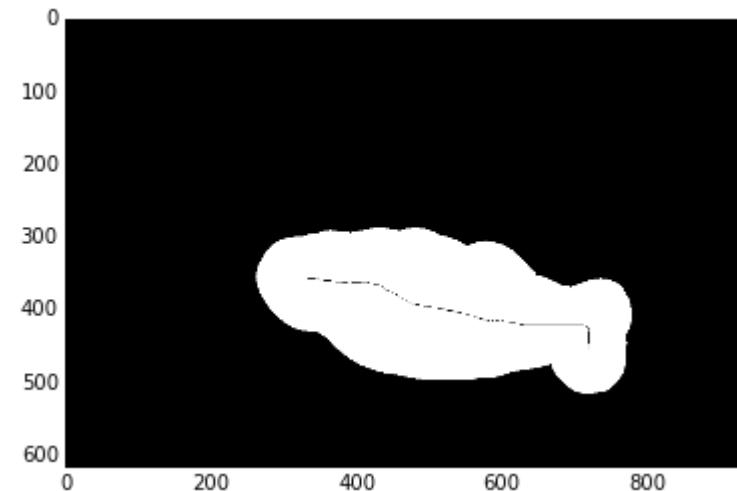
Metodologia

8) Esquelitização

Método 1: Regressão polinomial



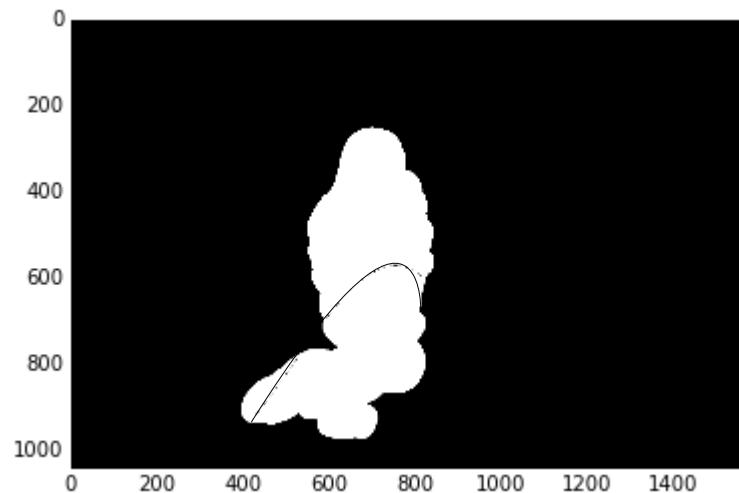
Método 2: Eixo Medial



Metodologia

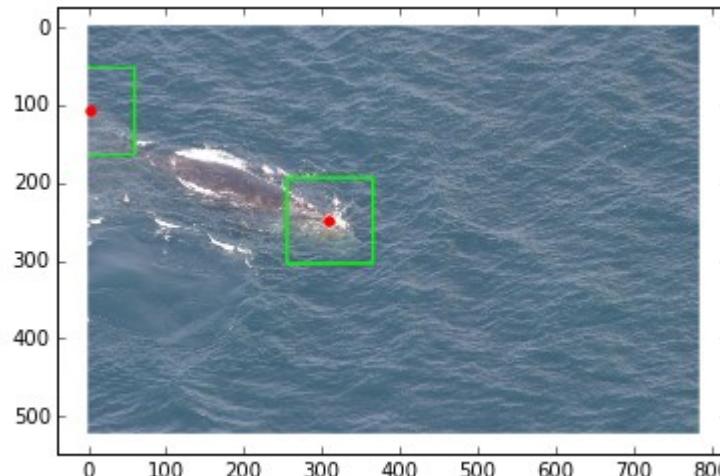
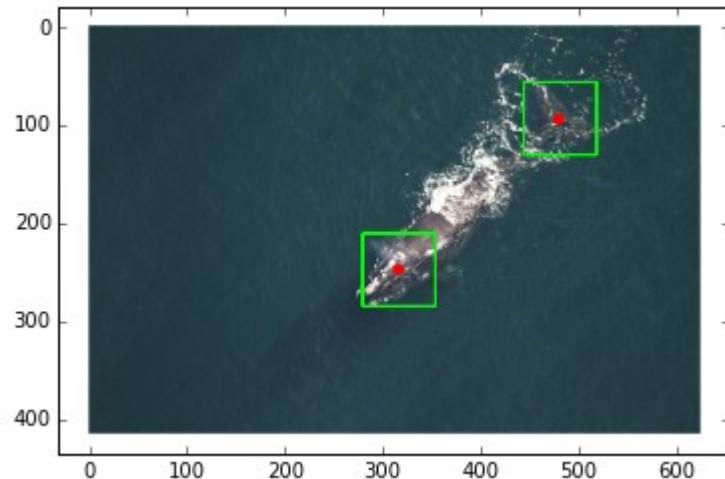
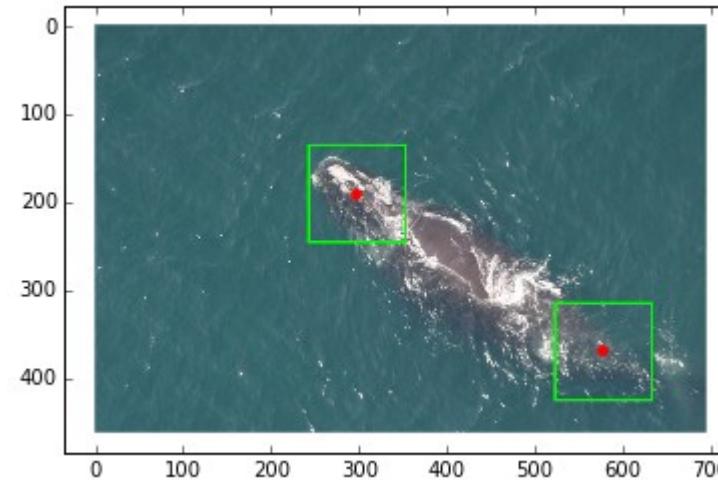
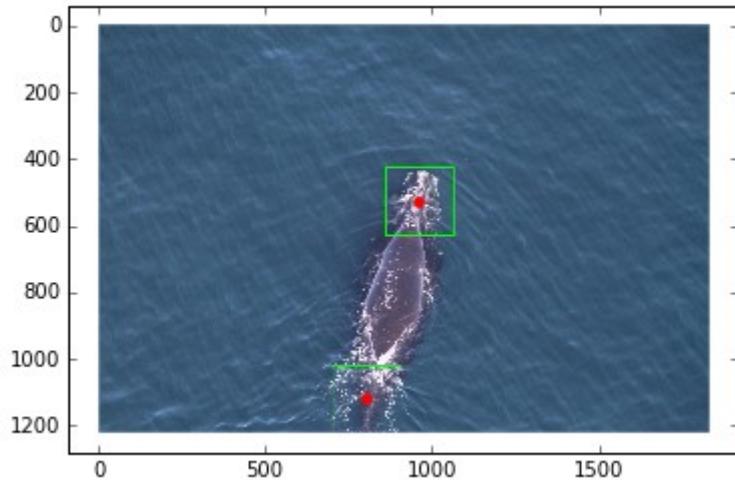
8) Esquelitização

Método 1: Regressão polinomial

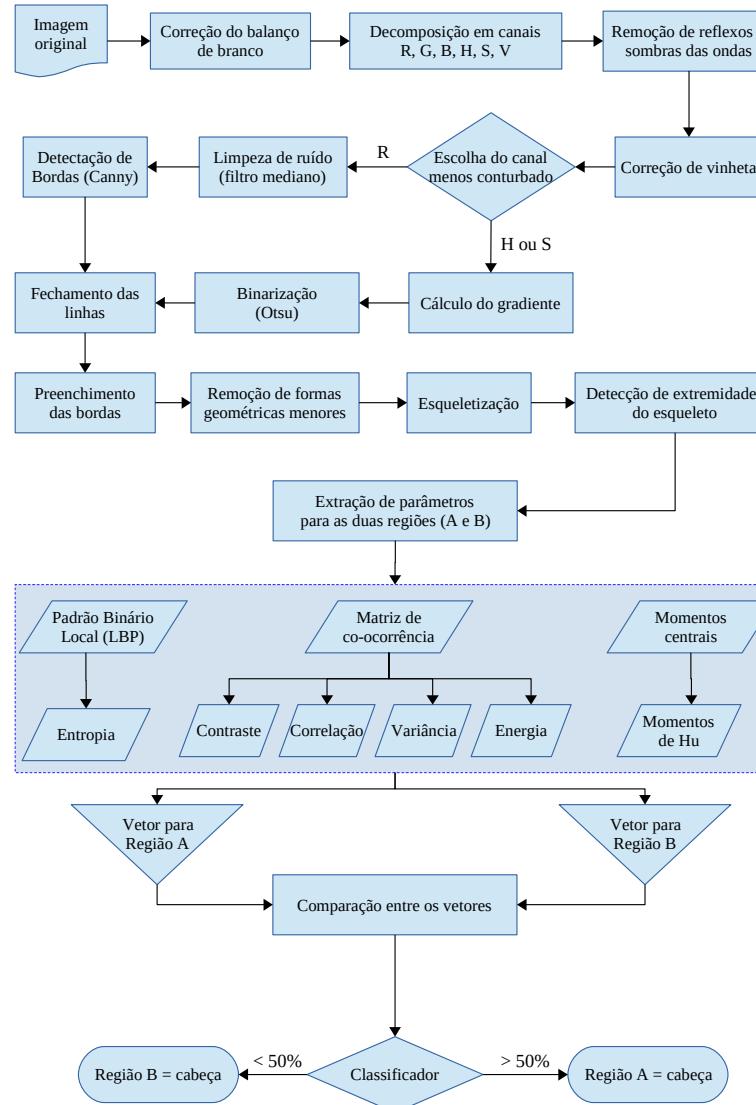


Metodologia

9) Busca pelas extremidades do esqueleto

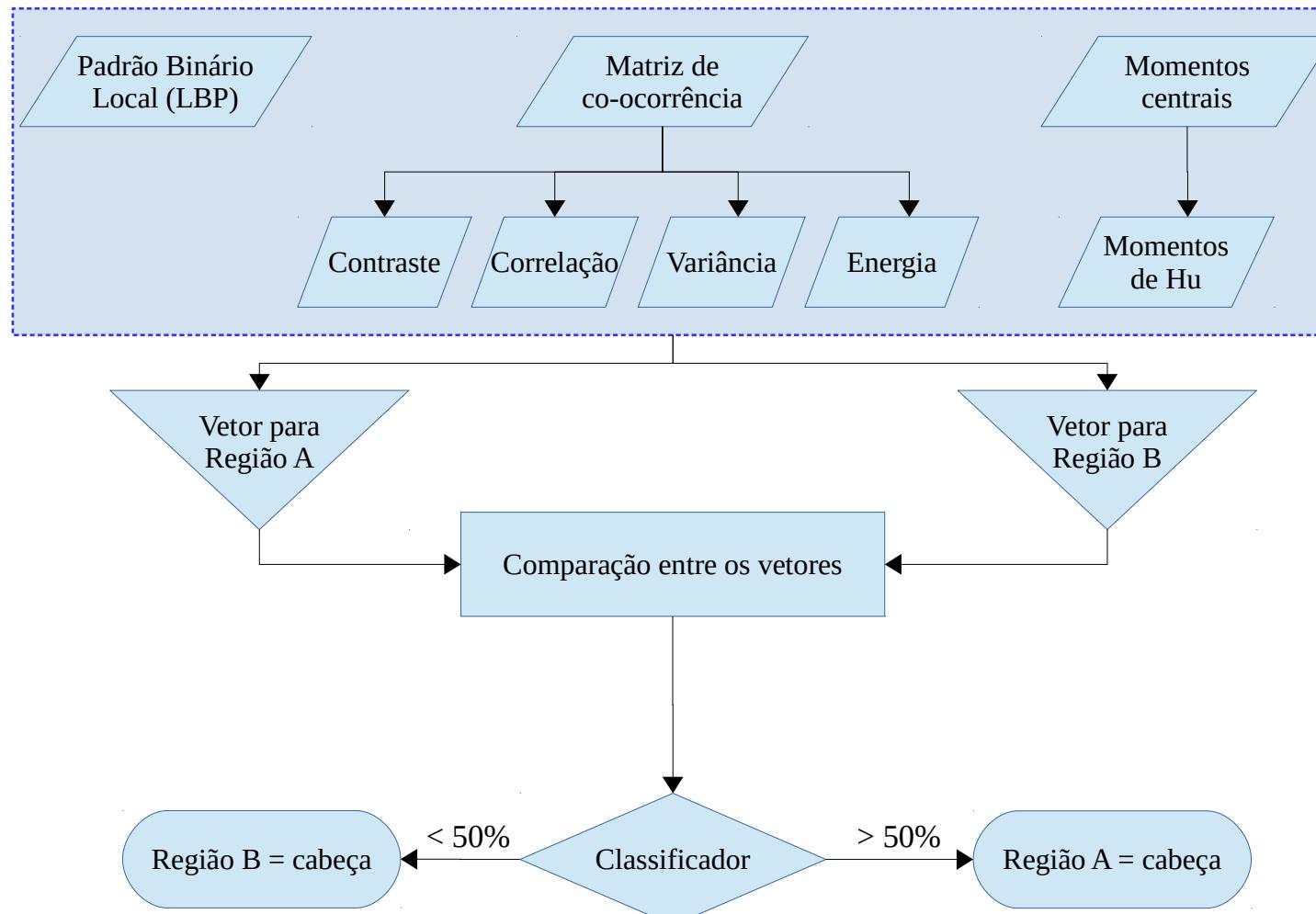


Metodologia



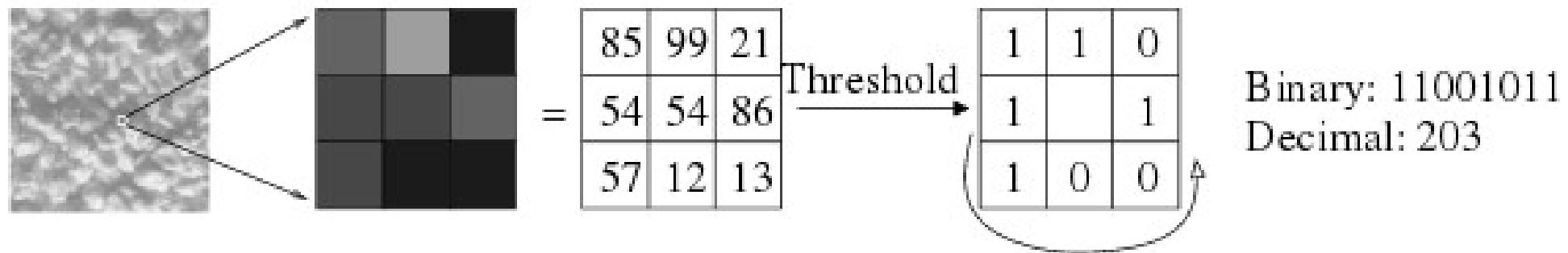
Você está aqui

Metodologia



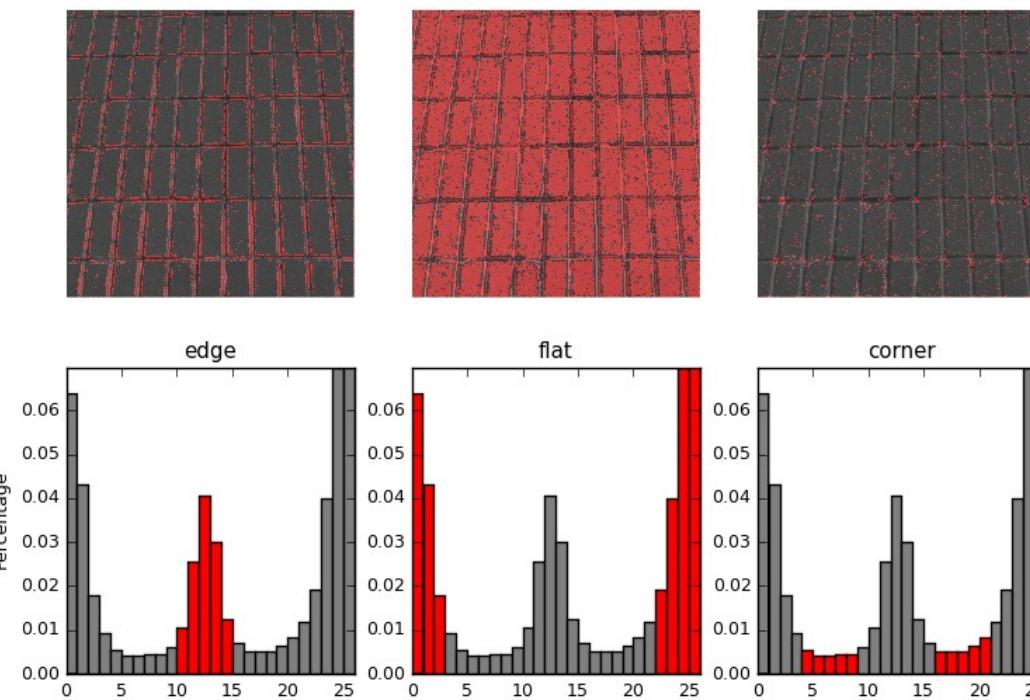
Metodologia

- Cálculo de parâmetros da imagem
 - *Local Binary Pattern* (Padrão Binário Local) ou LBP



Metodologia

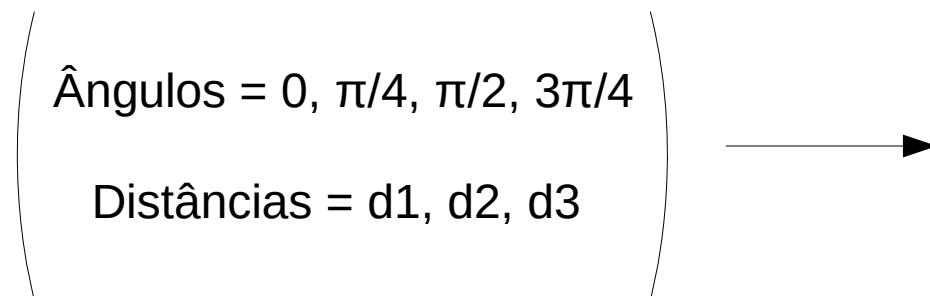
- Cálculo de parâmetros da imagem
 - *Local Binary Pattern* (Padrão Binário Local) ou LBP



Metodologia

- Cálculo de parâmetros da imagem

- Matriz de co-ocorrência $C(d, \theta)$
- Dependente do ângulo e distância



$C(d_1, 0)$
 $C(d_1, \pi/4)$
 $C(d_1, \pi/2)$
 $C(d_1, 3\pi/4)$
 $C(d_2, 0)$
 $C(d_2, \pi/4)$
 $C(d_2, \pi/2)$
 $C(d_2, 3\pi/4)$
 $C(d_3, 0)$
 $C(d_3, \pi/4)$
 $C(d_3, \pi/2)$
 $C(d_3, 3\pi/4)$

Metodologia

- Cálculo de parâmetros da imagem
 - Matriz de co-ocorrência

Contraste $\sum_{i,j=0}^{niveis-1} P_{i,j}(i-j)^2$

Correlação $\sum_{i,j=0}^{niveis-1} P_{i,j} \left[\frac{(i-\mu_i)(j-\mu_j)}{\sqrt{(\sigma_i^2)(\sigma_j^2)}} \right]$

Energia $\sqrt{\sum_{i,j=0}^{niveis-1} P_{i,j}^2}$

Homogeneidade $\sum_{i,j=0}^{niveis-1} \frac{P_{i,j}}{1+(i-j)^2}$

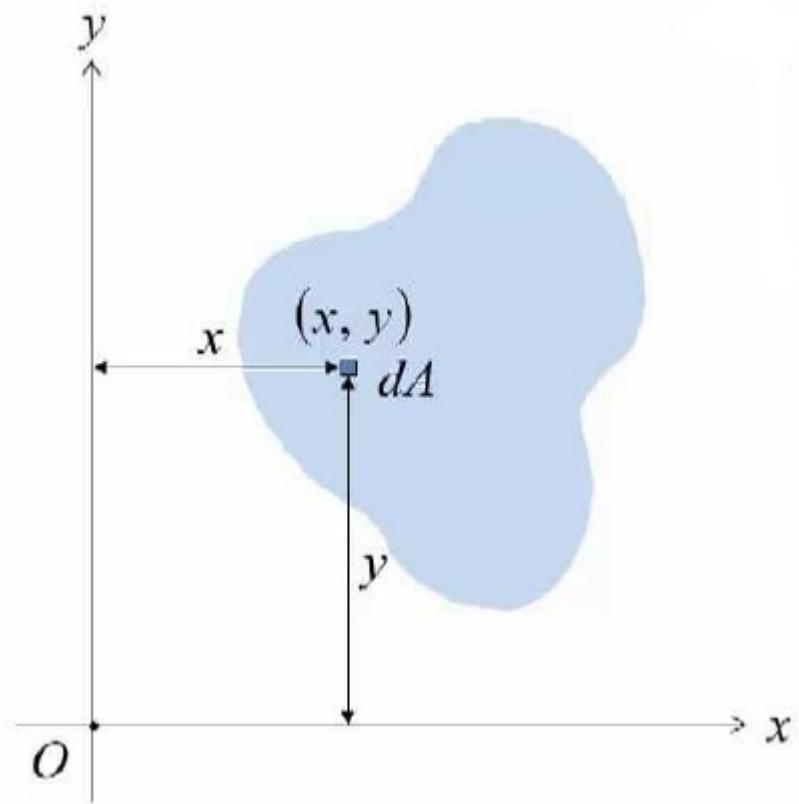
Parâmetros calculados 12 vezes (ou seja para cada matriz de co-ocorrência para Diferentes ângulos e distâncias.

Em seguida, obtém-se a média de cada um deles.

Metodologia

- Cálculo de parâmetros da imagem
 - Momentos de Hu

$$M_{ij} = \sum_x \sum_y x^i y^j I(x, y)$$



Metodologia

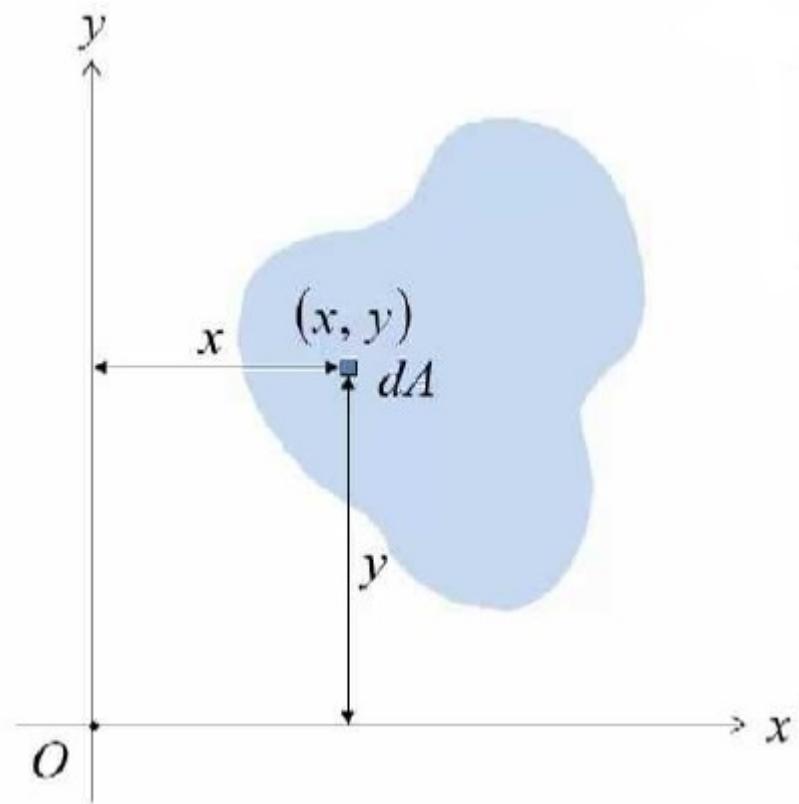
- Cálculo de parâmetros da imagem

- Momentos de Hu

$$M_{ij} = \sum_x \sum_y x^i y^j I(x, y)$$

$$\mu_{pq} = \sum_m^p \sum_n^q \binom{p}{m} \binom{q}{n} (-\bar{x})^{(p-m)} (-\bar{y})^{(q-n)} M_n$$

$$\bar{x} = \frac{M_{10}}{M_{00}} \quad \text{e} \quad \bar{y} = \frac{M_{01}}{M_{00}}$$



Metodologia

- Cálculo de parâmetros da imagem

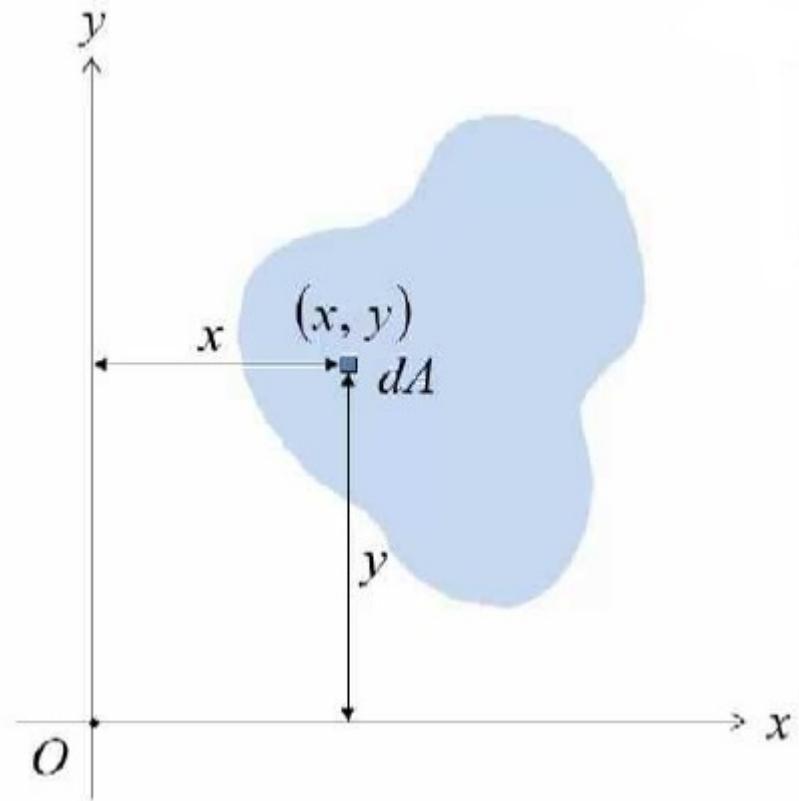
- Momentos de Hu

$$M_{ij} = \sum_x \sum_y x^i y^j I(x, y)$$

$$\mu_{pq} = \sum_m \sum_n \binom{p}{m} \binom{q}{n} (-\bar{x})^{(p-m)} (-\bar{y})^{(q-n)} M_n$$

$$\bar{x} = \frac{M_{10}}{M_{00}} \quad \text{e} \quad \bar{y} = \frac{M_{01}}{M_{00}}$$

$$v_{ij} = \frac{\mu_{ij}}{\mu_{00}^{\frac{(1+i+j)}{2}}}$$



Metodologia

- Cálculo de parâmetros da imagem

- Momentos de Hu

$$M_{I_1} = \eta_{20} + \eta_{02}$$

$$I_2 = (\eta_{20} - \eta_{02})^2 + 4\eta_{11}^2$$

$$I_3 = (\eta_{30} - 3\eta_{12})^2 + (3\eta_{21} - \eta_{03})^2$$

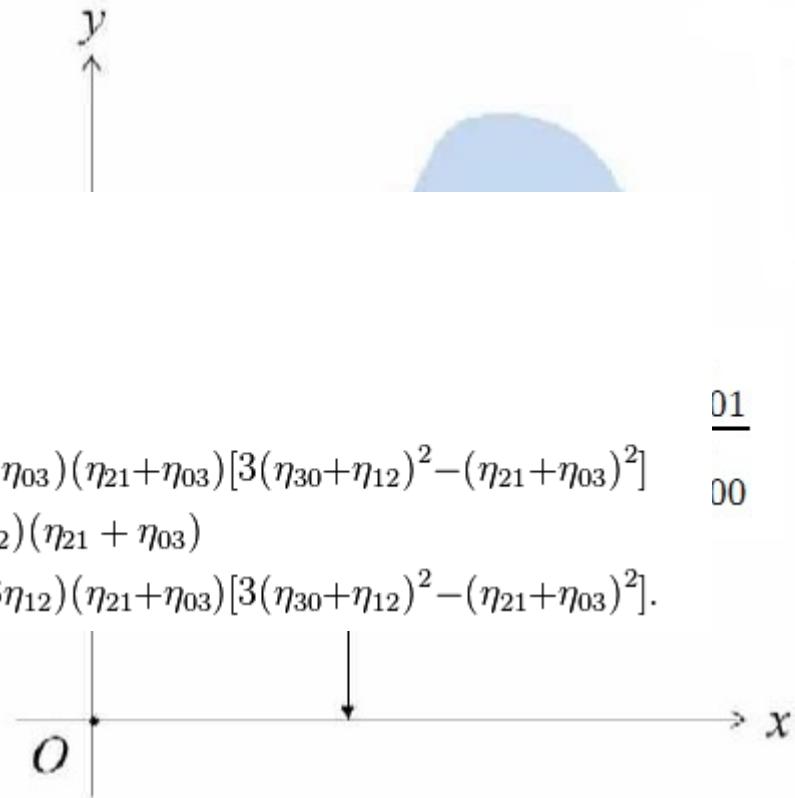
$$I_4 = (\eta_{30} + \eta_{12})^2 + (\eta_{21} + \eta_{03})^2$$

$$\mu_1 I_5 = (\eta_{30} - 3\eta_{12})(\eta_{30} + \eta_{12})[(\eta_{30} + \eta_{12})^2 - 3(\eta_{21} + \eta_{03})^2] + (3\eta_{21} - \eta_{03})(\eta_{21} + \eta_{03})[3(\eta_{30} + \eta_{12})^2 - (\eta_{21} + \eta_{03})^2]$$

$$I_6 = (\eta_{20} - \eta_{02})[(\eta_{30} + \eta_{12})^2 - (\eta_{21} + \eta_{03})^2] + 4\eta_{11}(\eta_{30} + \eta_{12})(\eta_{21} + \eta_{03})$$

$$I_7 = (3\eta_{21} - \eta_{03})(\eta_{30} + \eta_{12})[(\eta_{30} + \eta_{12})^2 - 3(\eta_{21} + \eta_{03})^2] - (\eta_{30} - 3\eta_{12})(\eta_{21} + \eta_{03})[3(\eta_{30} + \eta_{12})^2 - (\eta_{21} + \eta_{03})^2].$$

$$\nu_{ij} = \frac{\mu_{ij}}{\mu_{00}}$$



Metodologia

- Cálculo de parâmetros da imagem

- Momentos de Hu

$$M_{I_1} = \eta_{20} + \eta_{02}$$

$$I_2 = (\eta_{20} - \eta_{02})^2 +$$

$$I_3 = (\eta_{30} - 3\eta_{12})^2 -$$

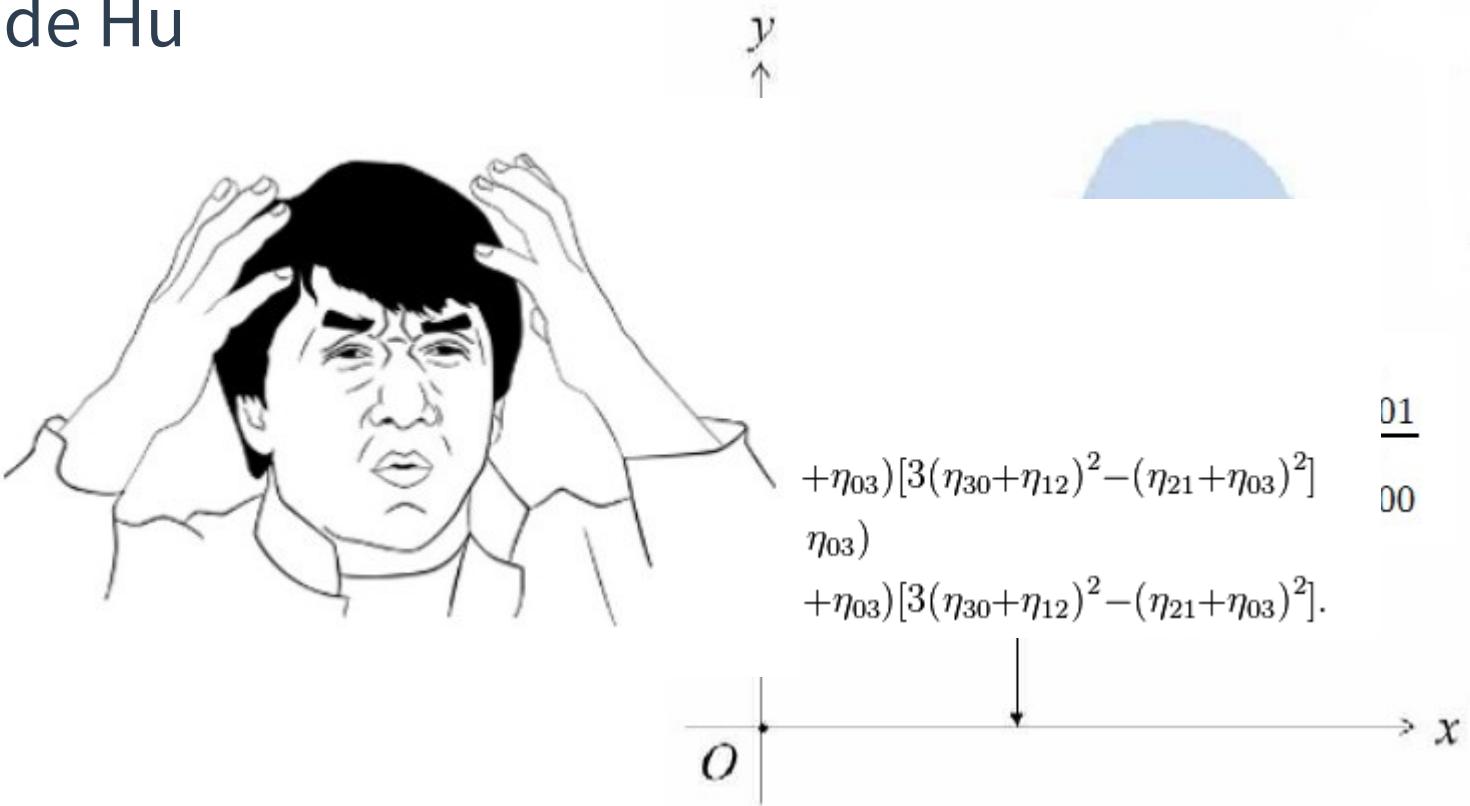
$$I_4 = (\eta_{30} + \eta_{12})^2 +$$

$$\mu_I I_5 = (\eta_{30} - 3\eta_{12})(\eta_{30} +$$

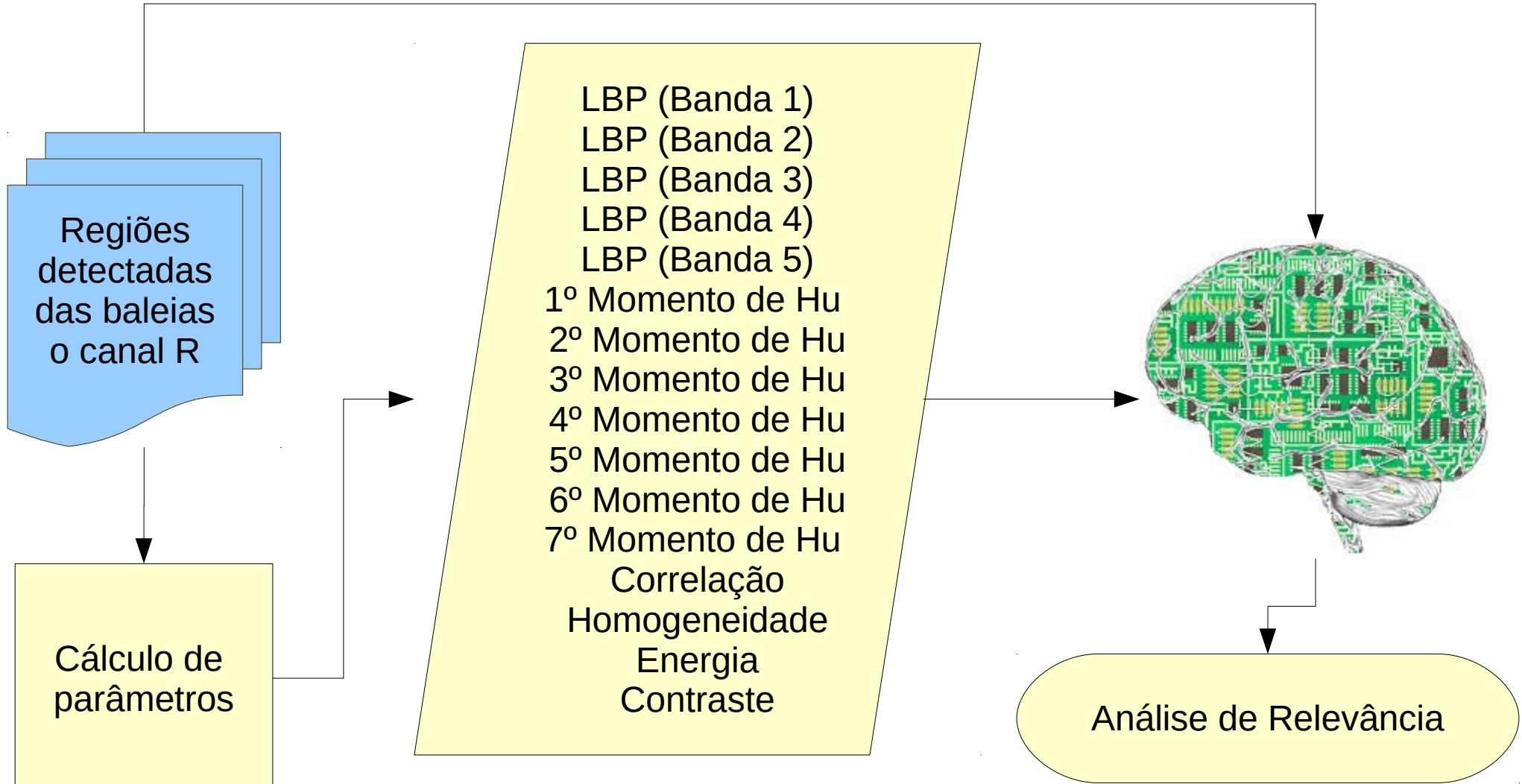
$$I_6 = (\eta_{20} - \eta_{02})[(\eta_{30} +$$

$$I_7 = (3\eta_{21} - \eta_{03})(\eta_{30} +$$

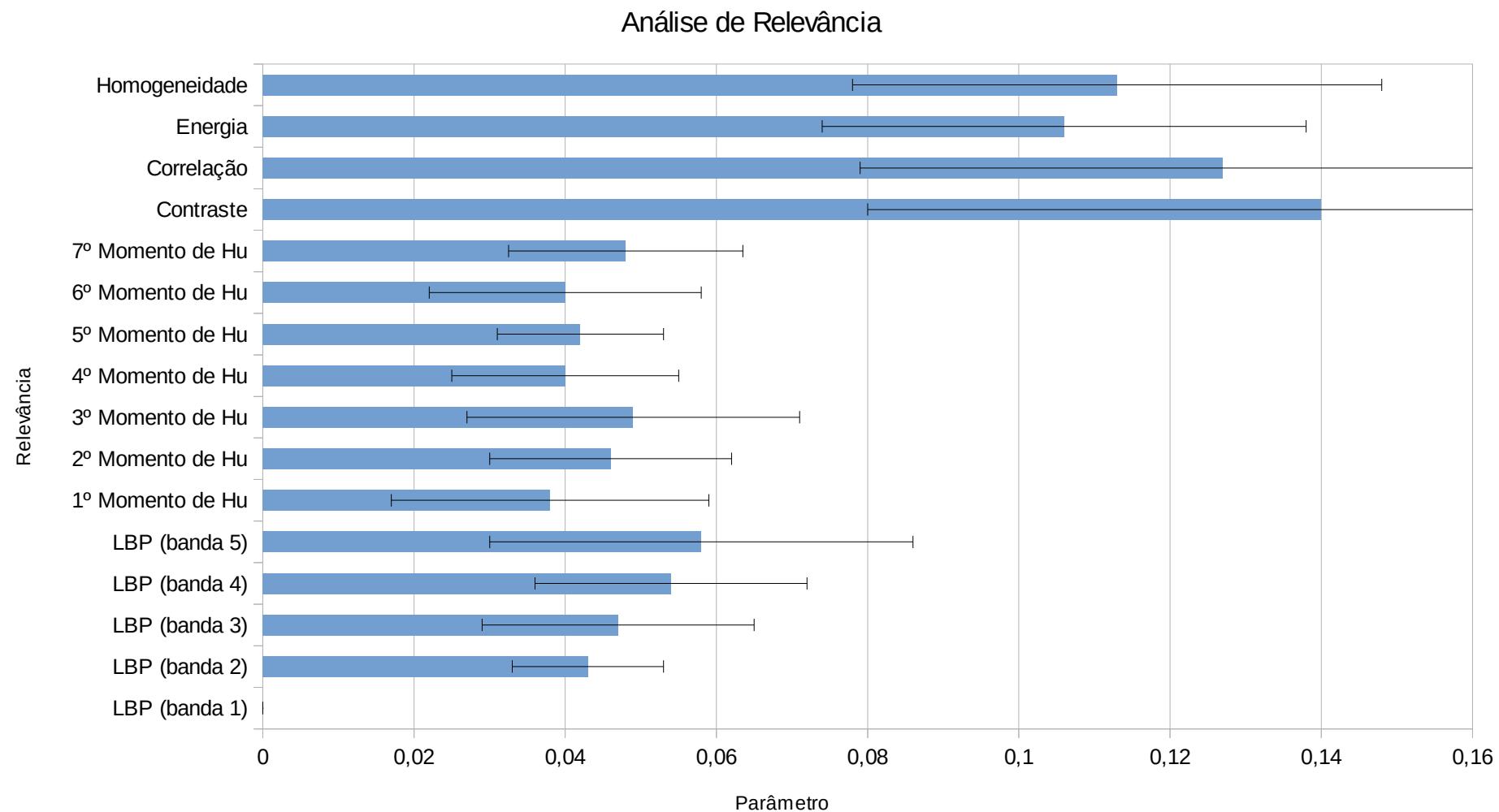
$$\nu_{ij} = \frac{\eta_{ij}}{\mu_{00}}$$



Resultados

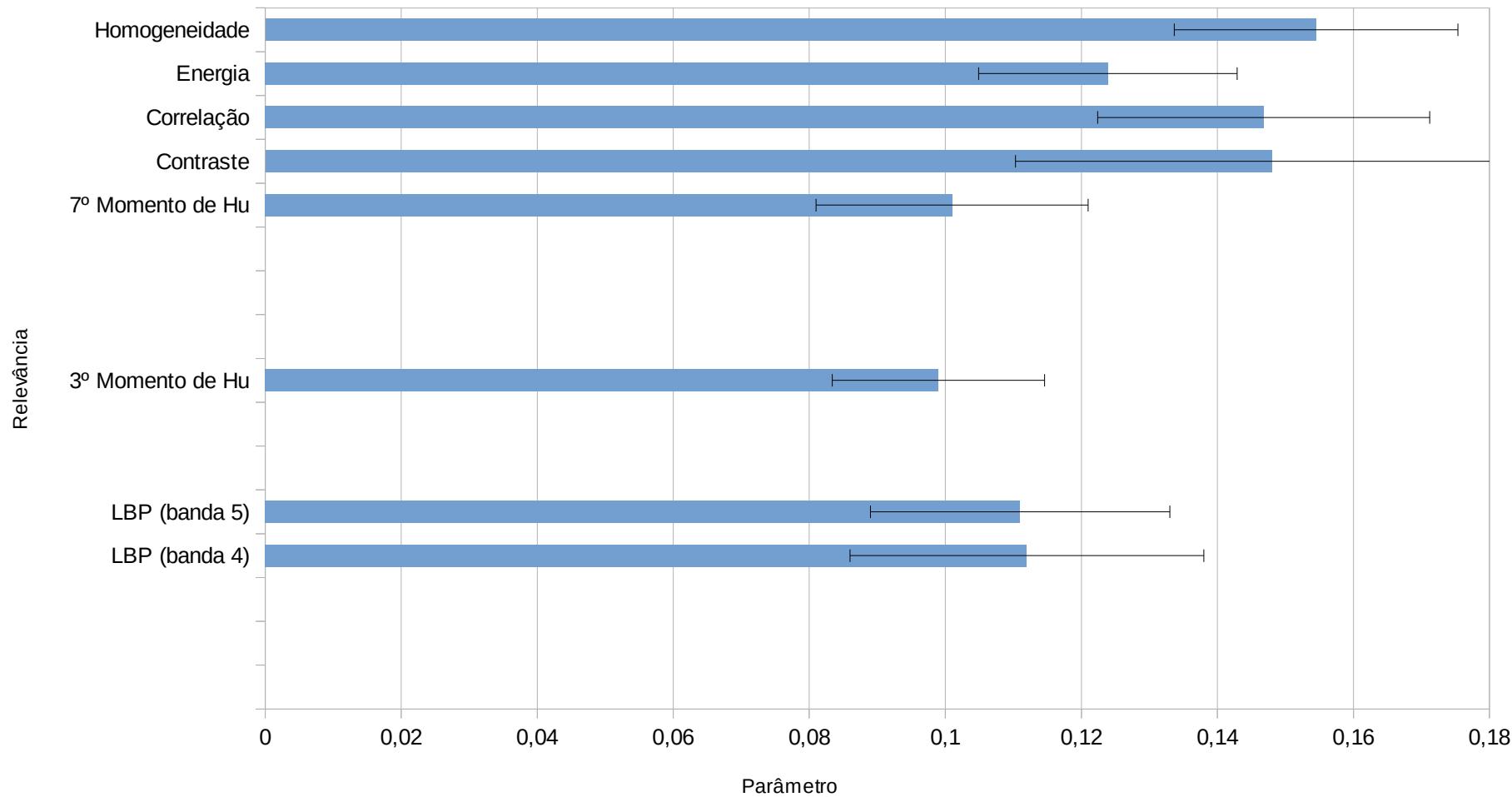


Resultados



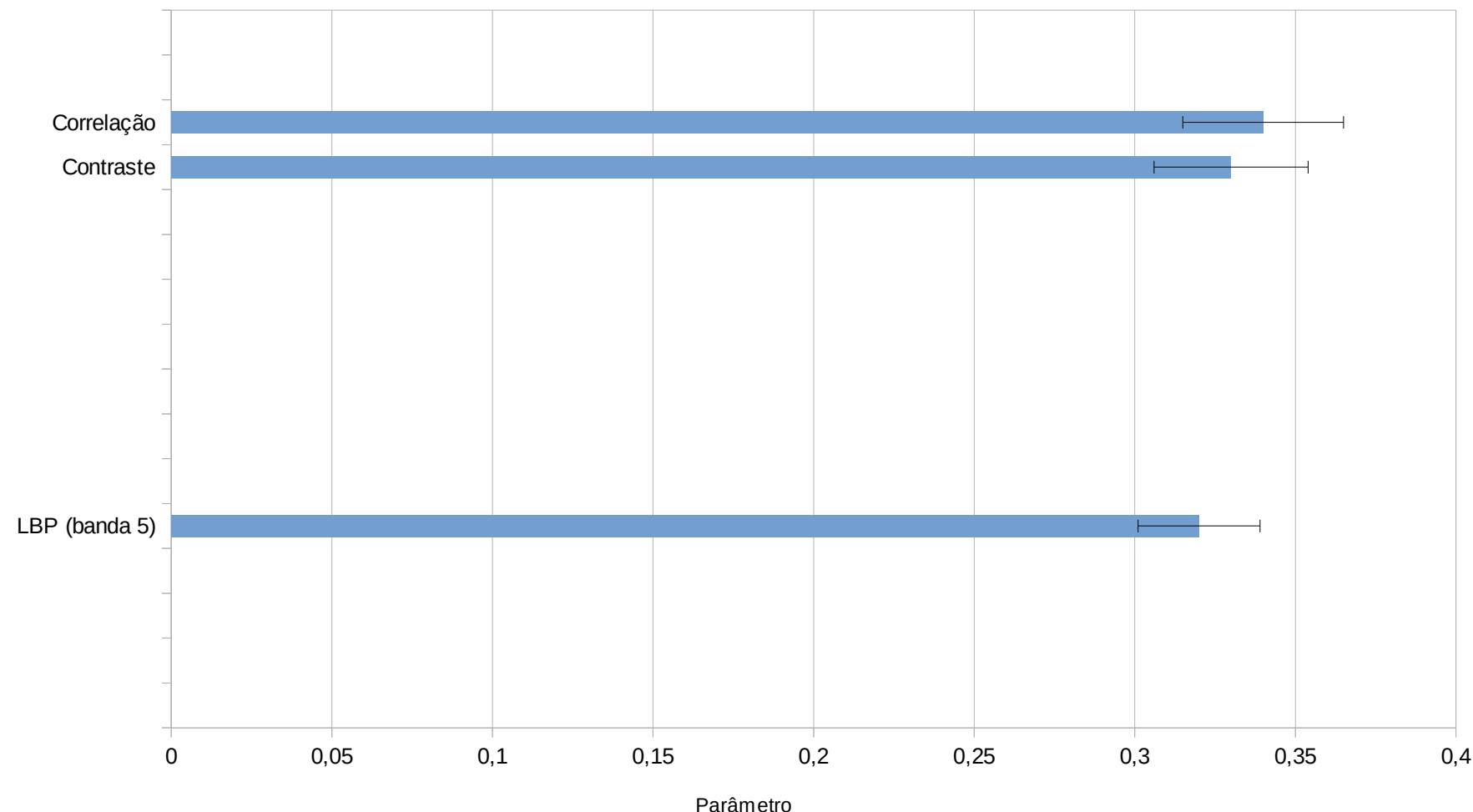
Resultados

Análise de Relevância

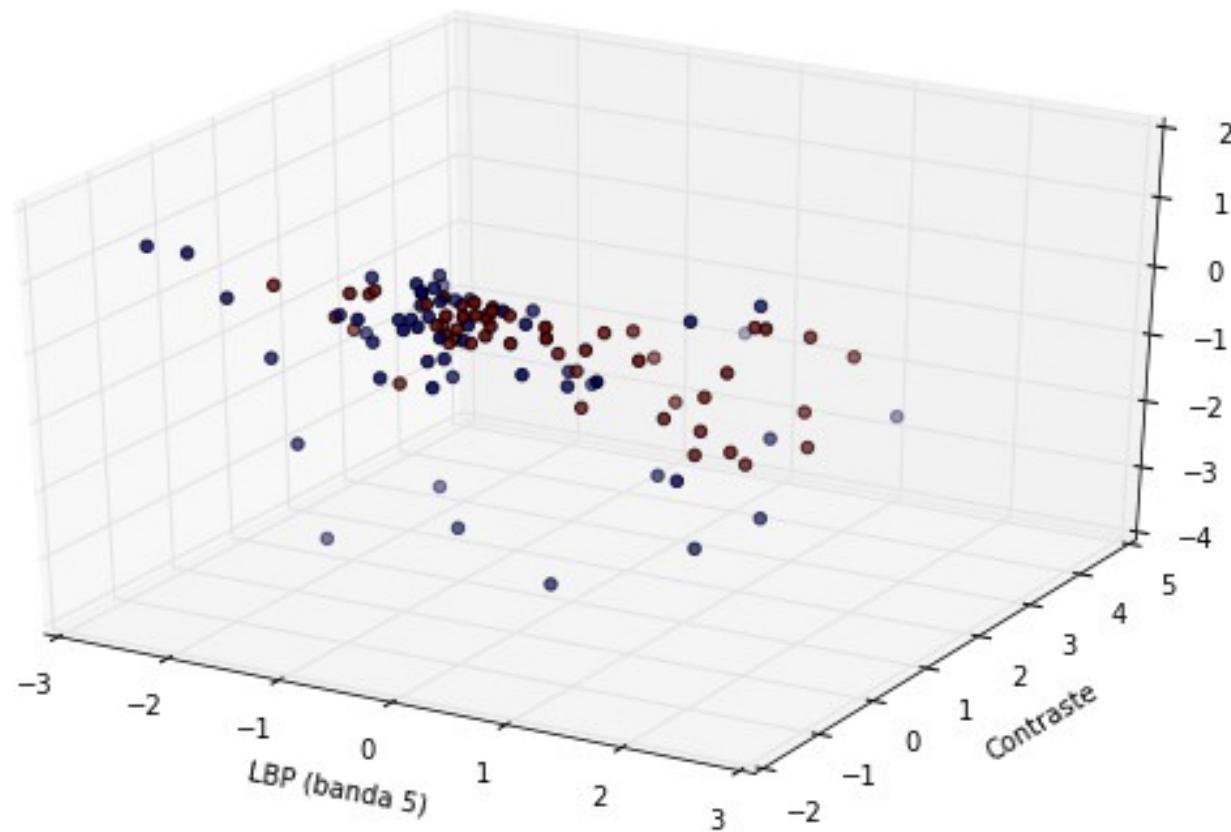


Resultados

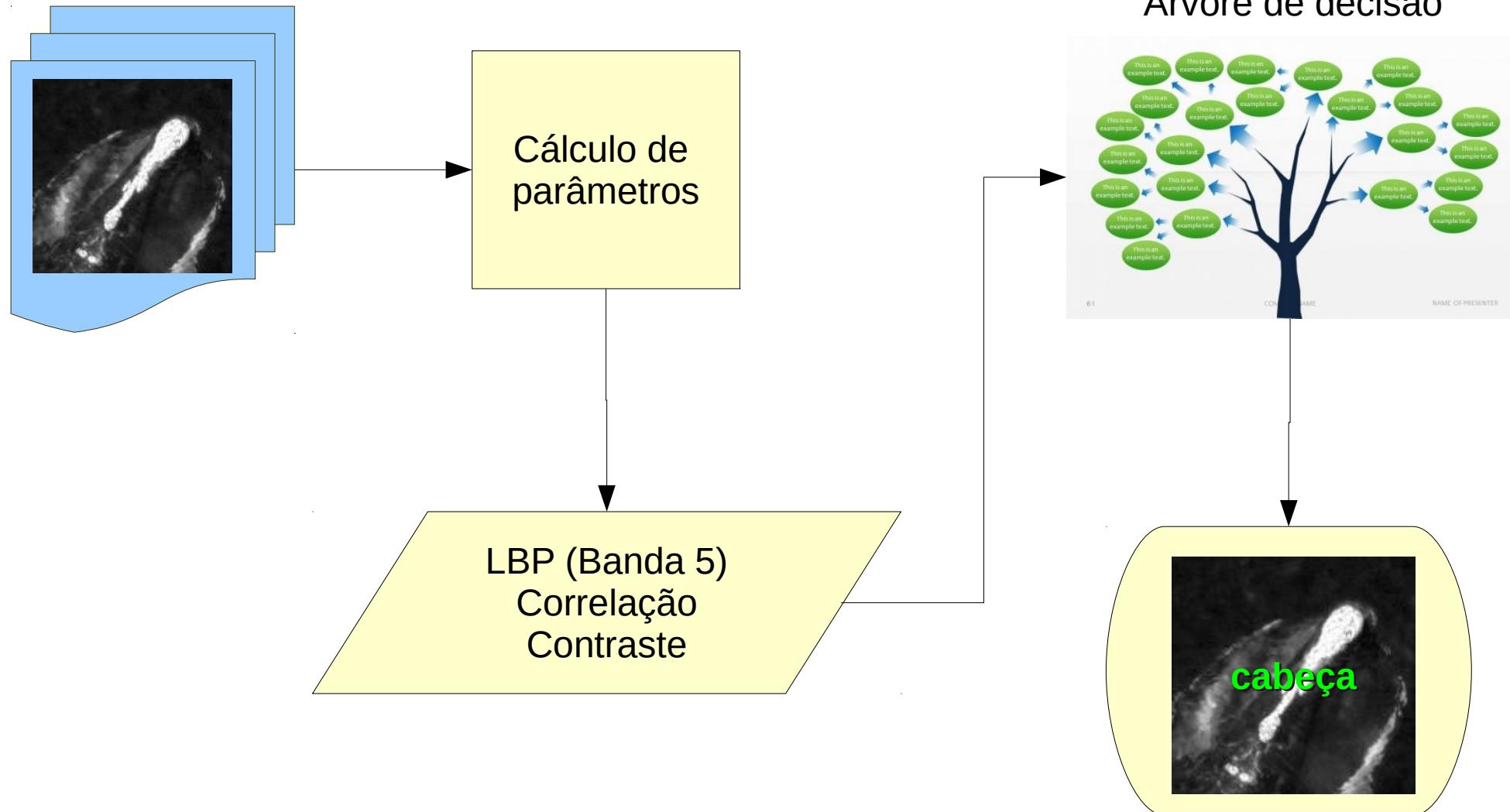
Análise de Relevância



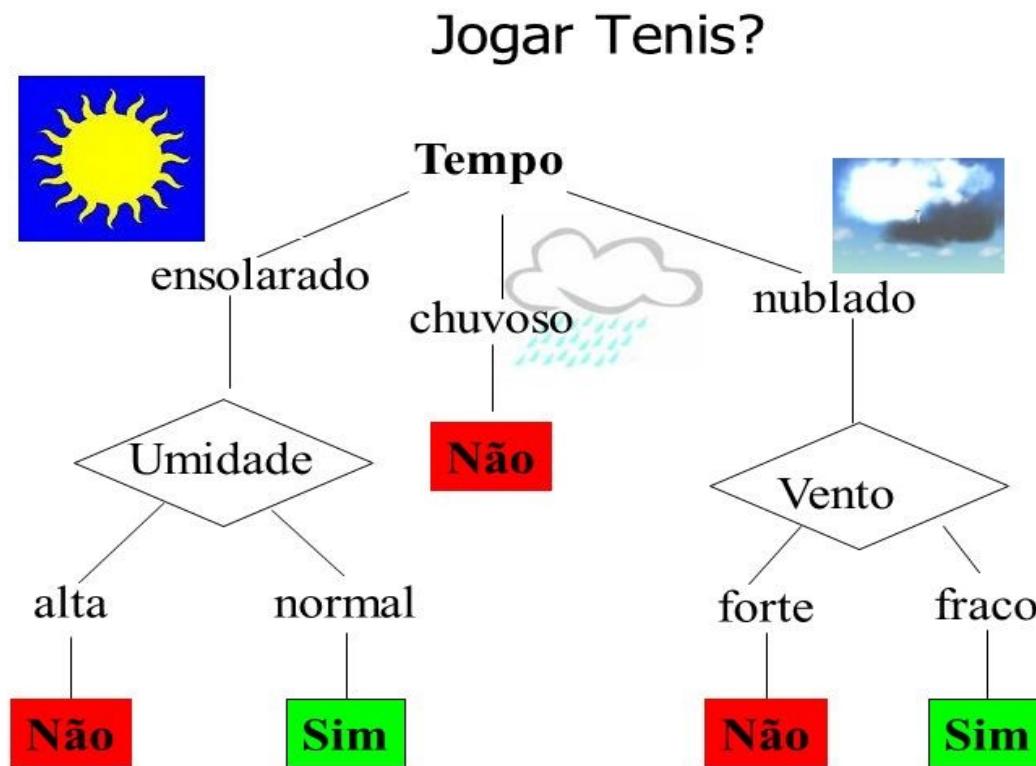
Resultados



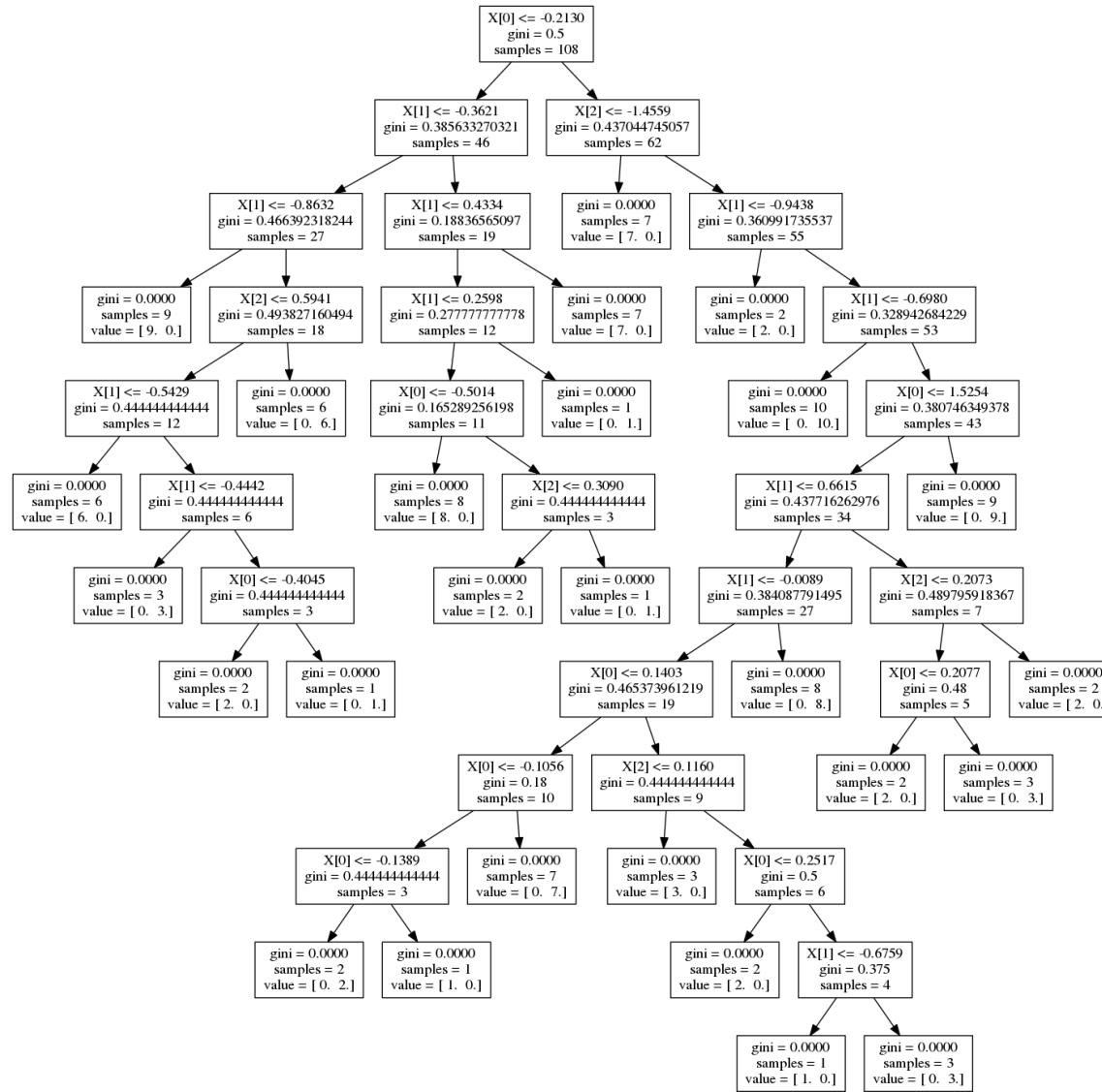
Resultados



Exemplo de árvore de decisão

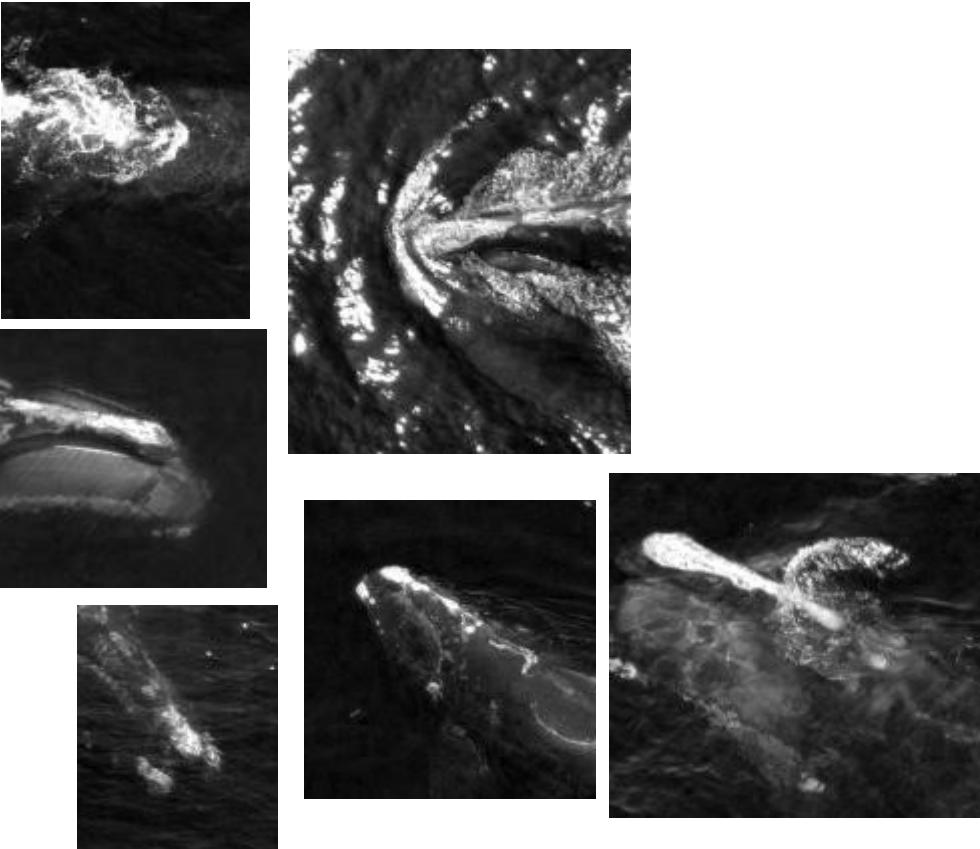


Resultados

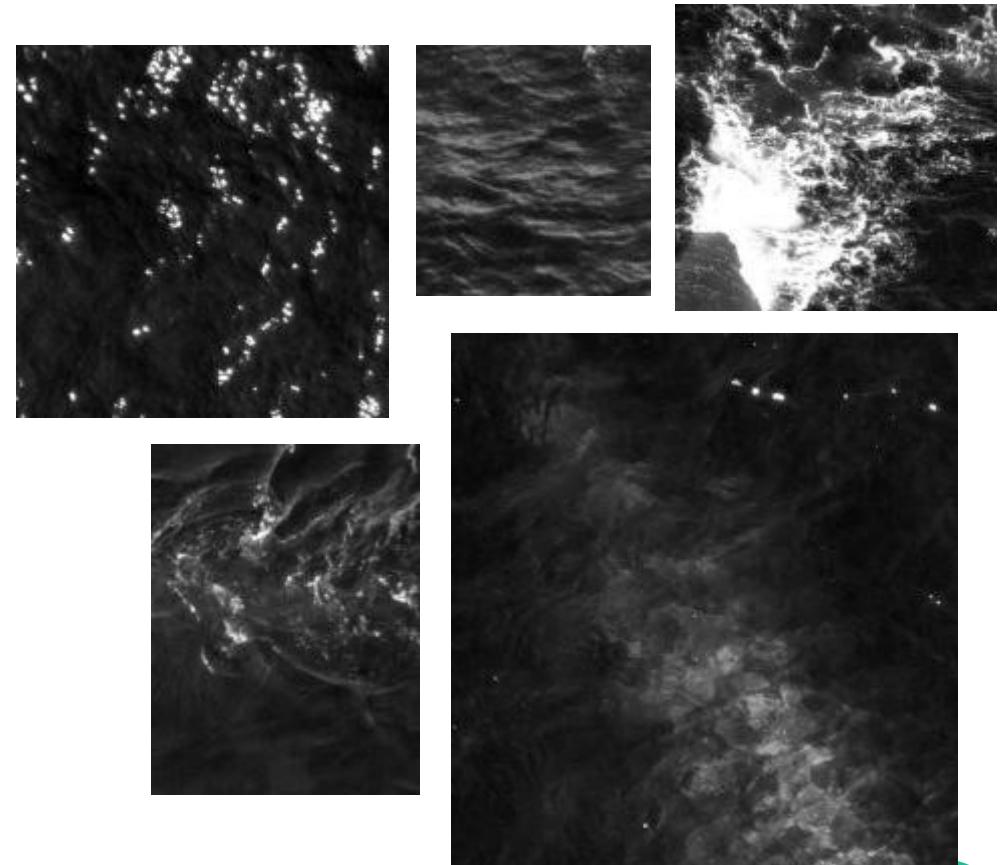


Resultados

Exemplos de imagens corretamente classificadas como **cabeça**

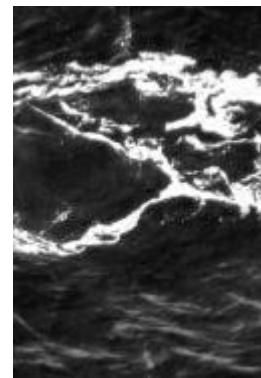
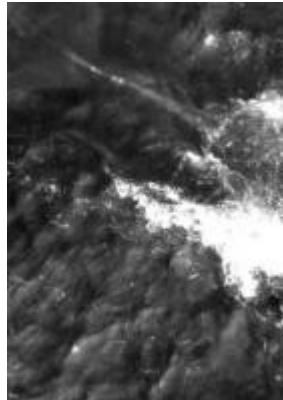


Exemplos de imagens corretamente classificadas como **não cabeça**

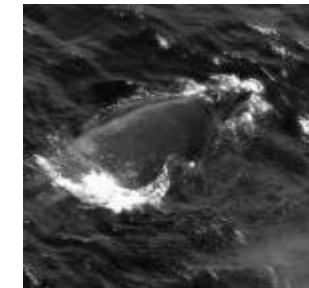


Resultados

Exemplos de falsos positivos



Exemplos de falsos negativos



Resultados

Algoritmo

AdaBoost (Decision Tree)

Treino

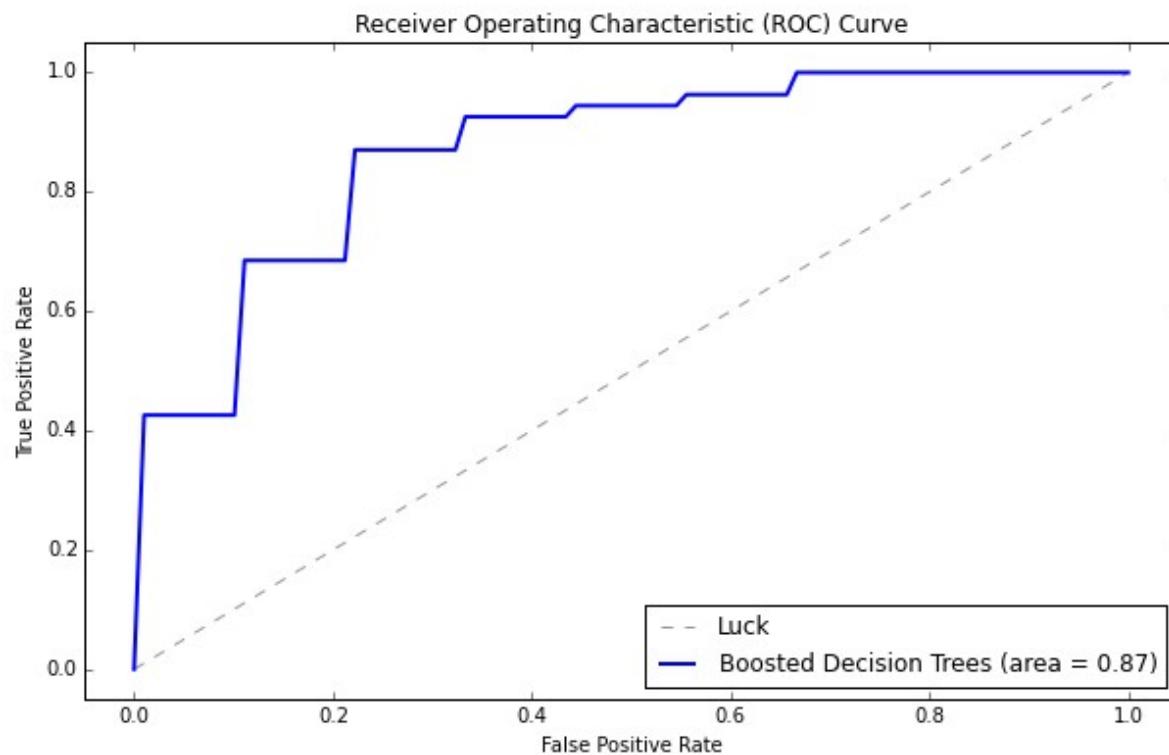
108 imagens

Shuffling

6-folds

Resultado

Área ROC = 0.87



Resultados

“The team first manually identified whales from the image and found 55 probable whales, 23 possible whales and 13 other underwater objects that were not whales, such as rocks. They then tested a series of automated image-processing systems, the best of which located 89 percent of the probable whales that they had counted manually, the team reports today (Feb. 12) in the journal PLOS ONE.”

LiveScience: “Hi-Res Satellites Help Track Whale Populations”

<http://www.livescience.com/43338-count-whales-using-satellites.html>