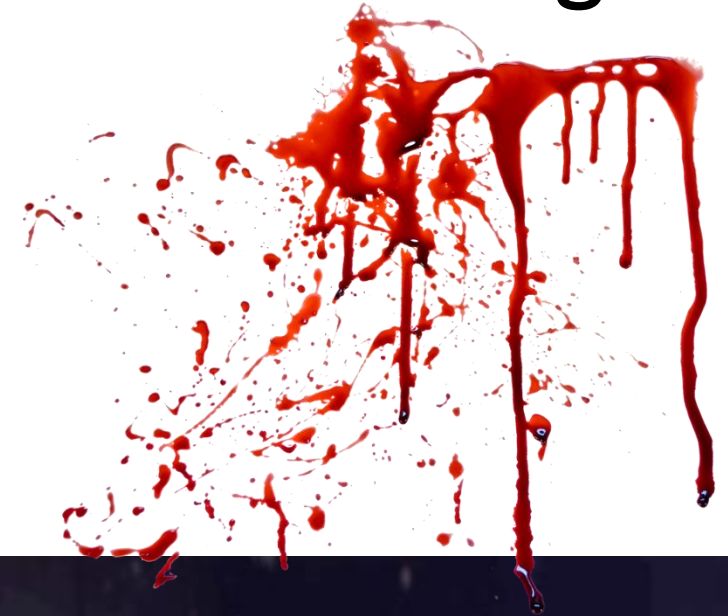


X Seminário Nacional de Crimes contra a Vida

Determinação do Ângulo de Impacto de Espargimentos de
Sangue: Proposta de Abordagem via Processamento Digital
de Imagens

Victor Hugo Costa Dias



X Seminário Nacional de Crimes contra a Vida

Victor Hugo Costa Dias

- Perito Criminal – Seção de Crimes contra a Pessoa/IC/PCDF
- Doutorando em Engenharia de Sistemas Eletrônicos e de Automação – UnB
- Mestre em Engenharia de Sistemas Eletrônicos e de Automação – UnB
- Engenheiro Mecatrônico – UnB



UnB

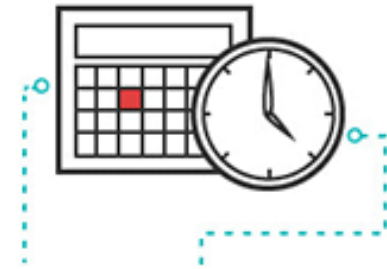


C A P E S

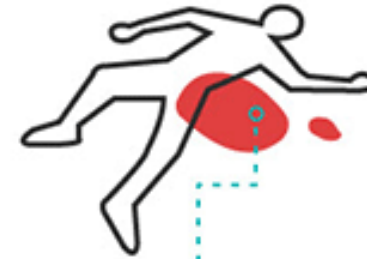


**POLÍCIA CIVIL
DO DISTRITO FEDERAL**

O que a análise de padrões de manchas de sangue pode determinar?



Date and time of crime



Movements/position of those involved

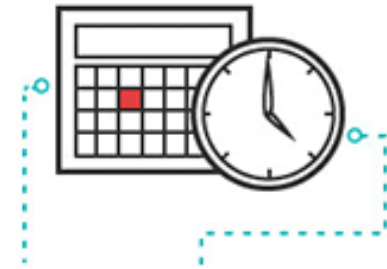


Type and velocity of weapon

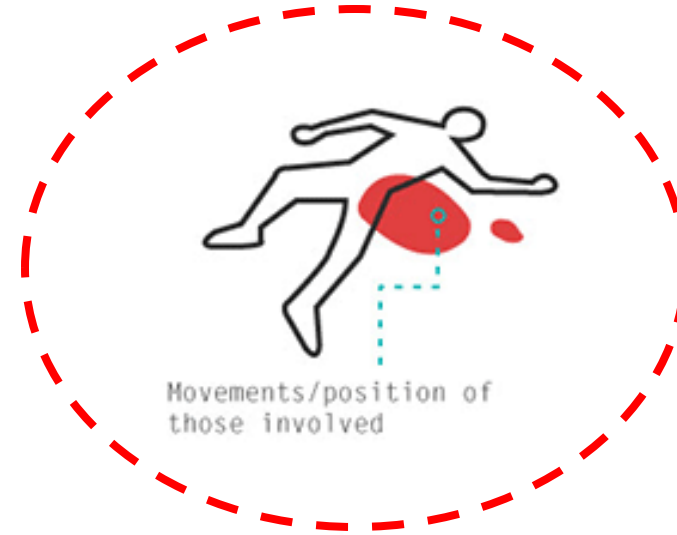


Types of injuries dealt

O que a análise de padrões de manchas de sangue pode determinar?



Date and time of crime



Movements/position of those involved

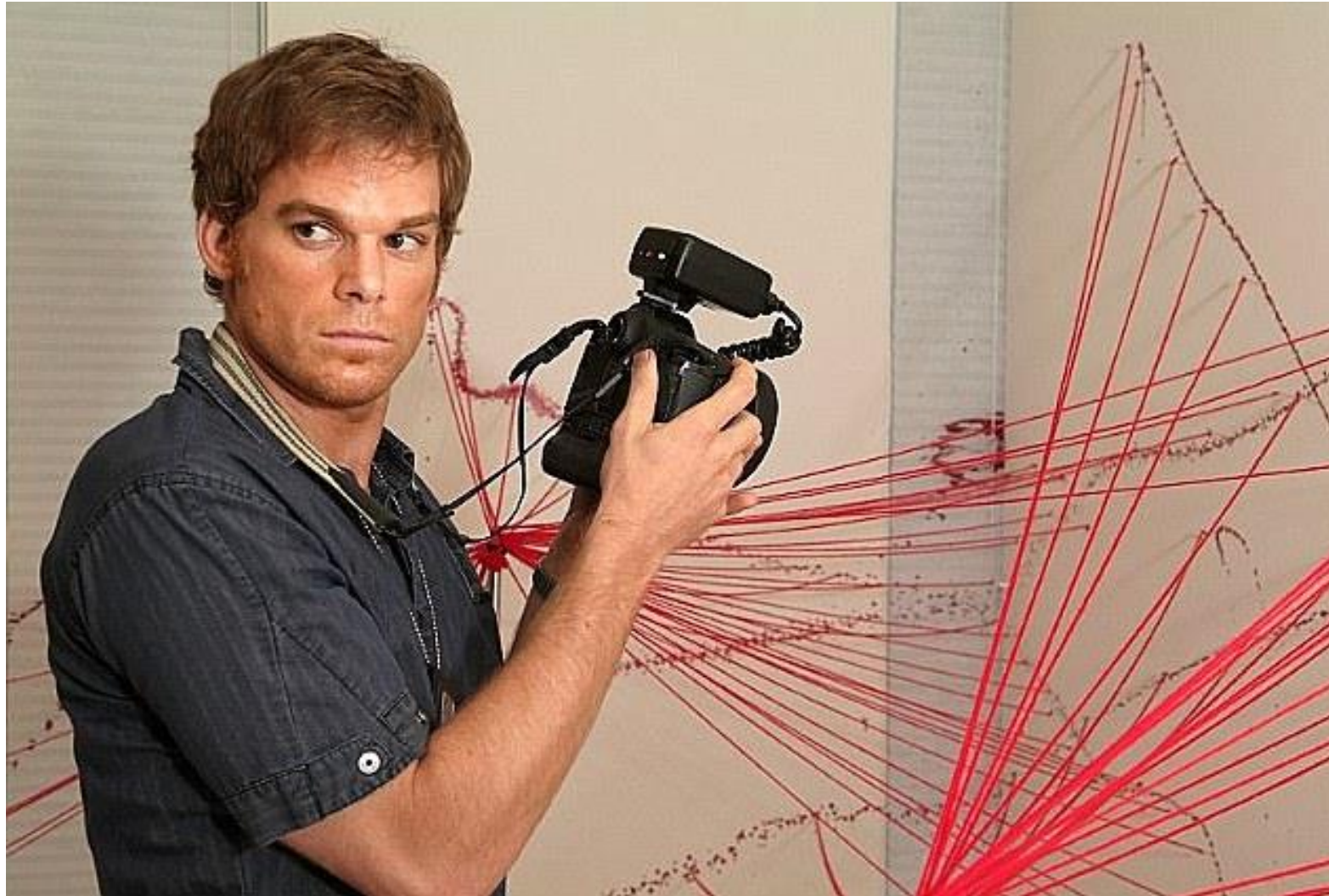


Type and velocity of weapon

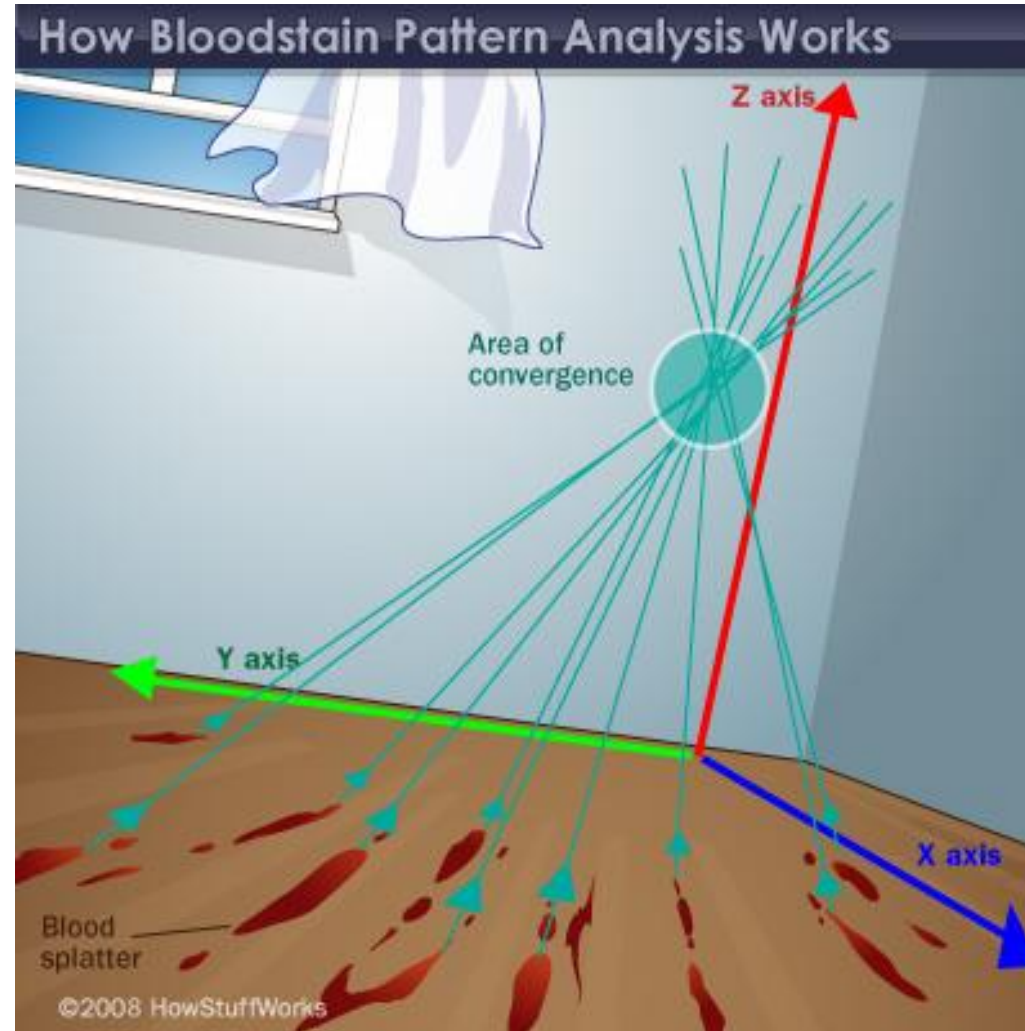


Types of injuries dealt

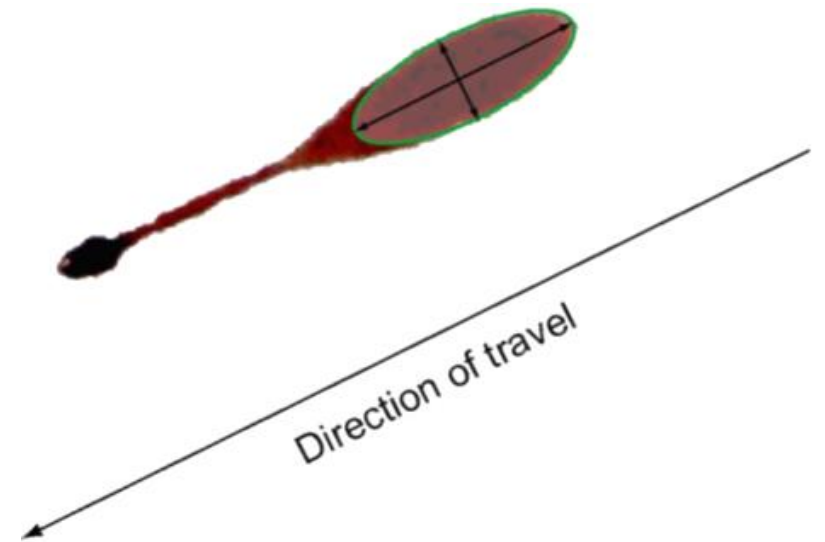
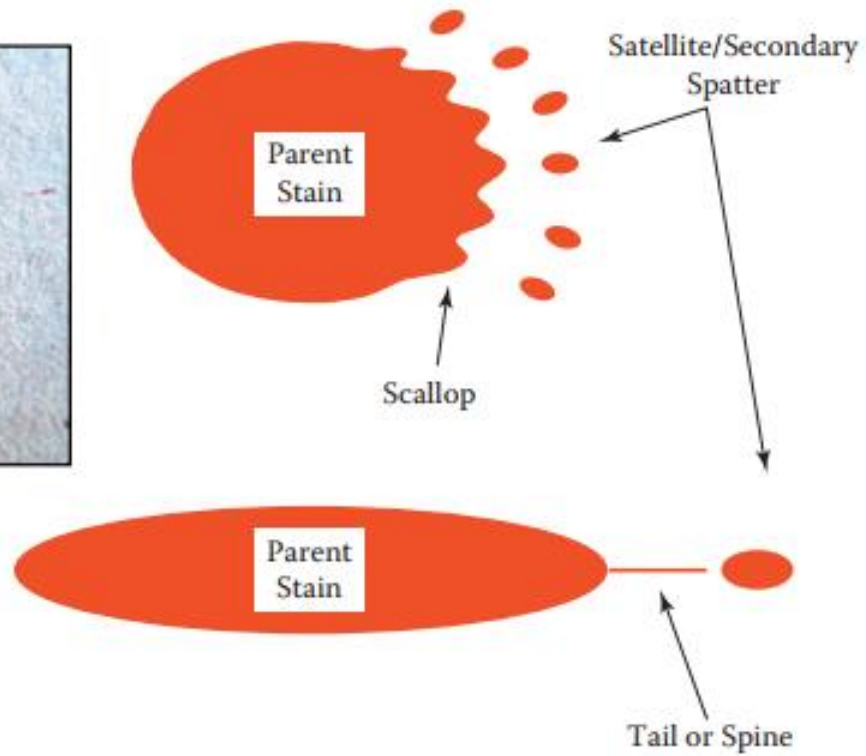
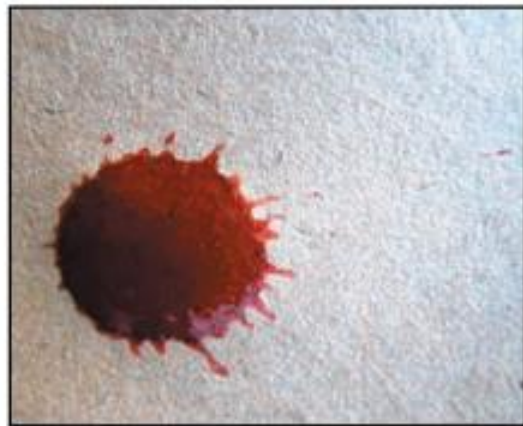
Como a determinação da área de origem é normalmente feita?



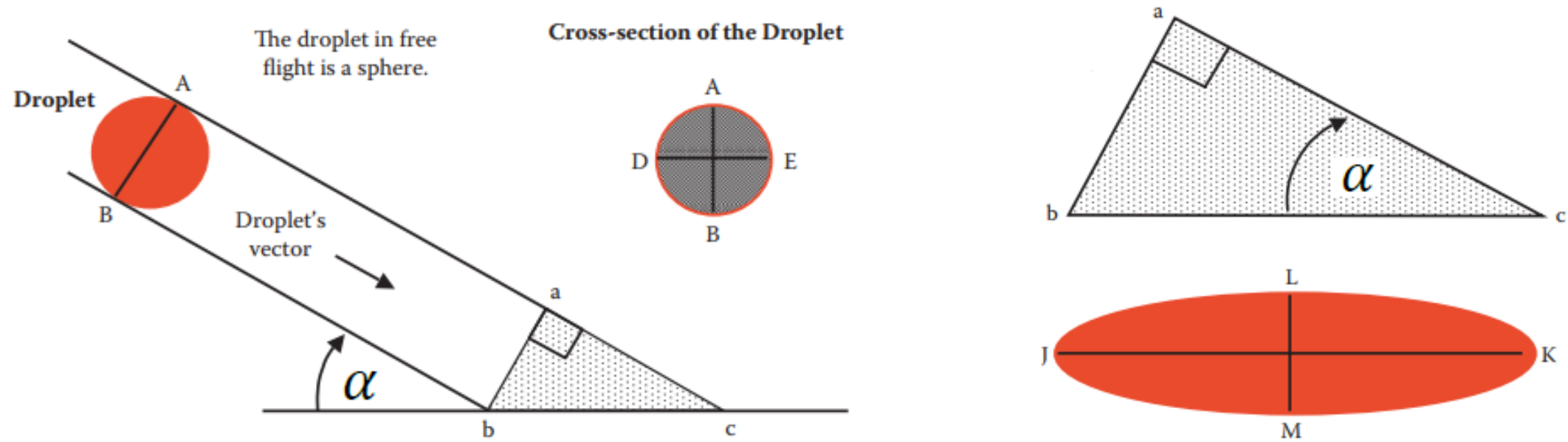
Como a determinação da área de origem é normalmente feita?



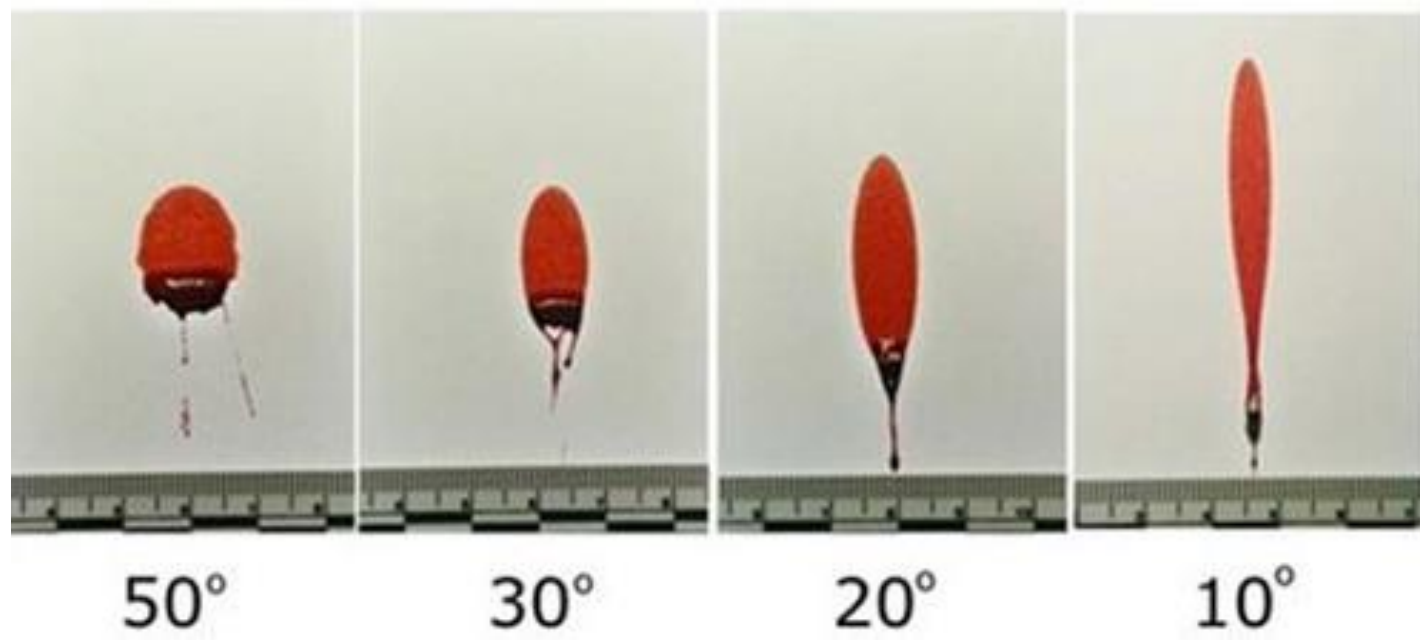
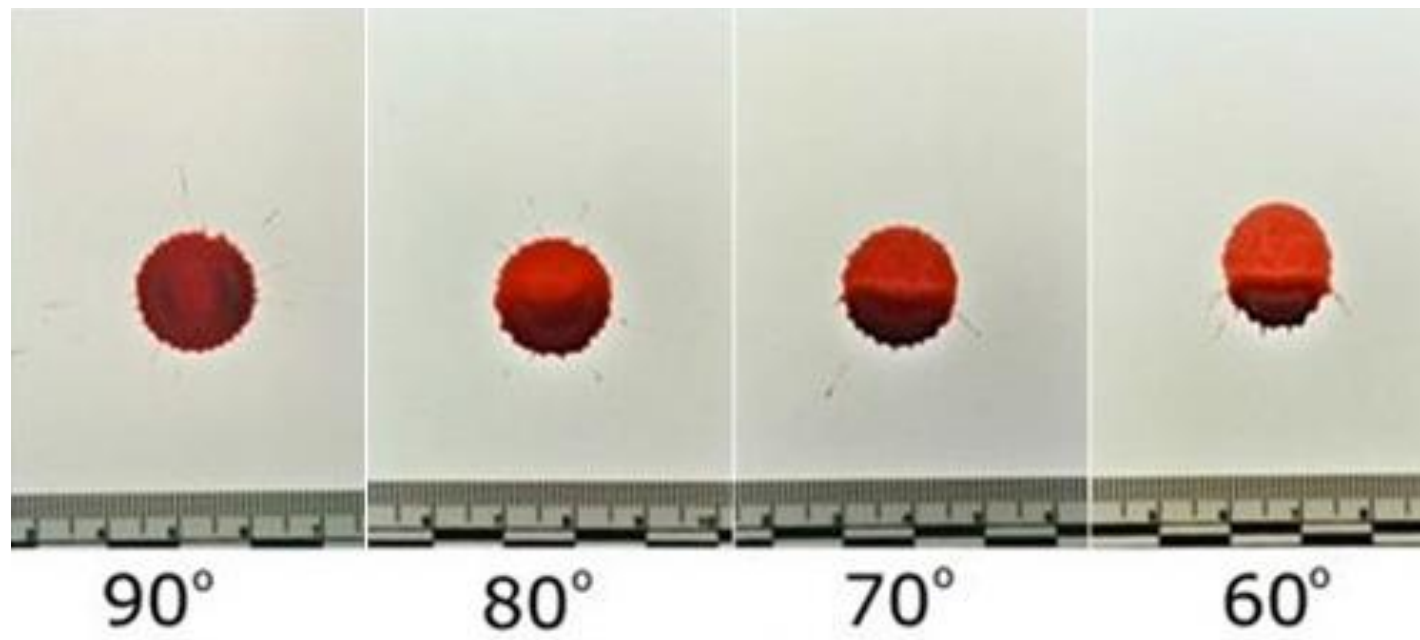
O Modelo Teórico

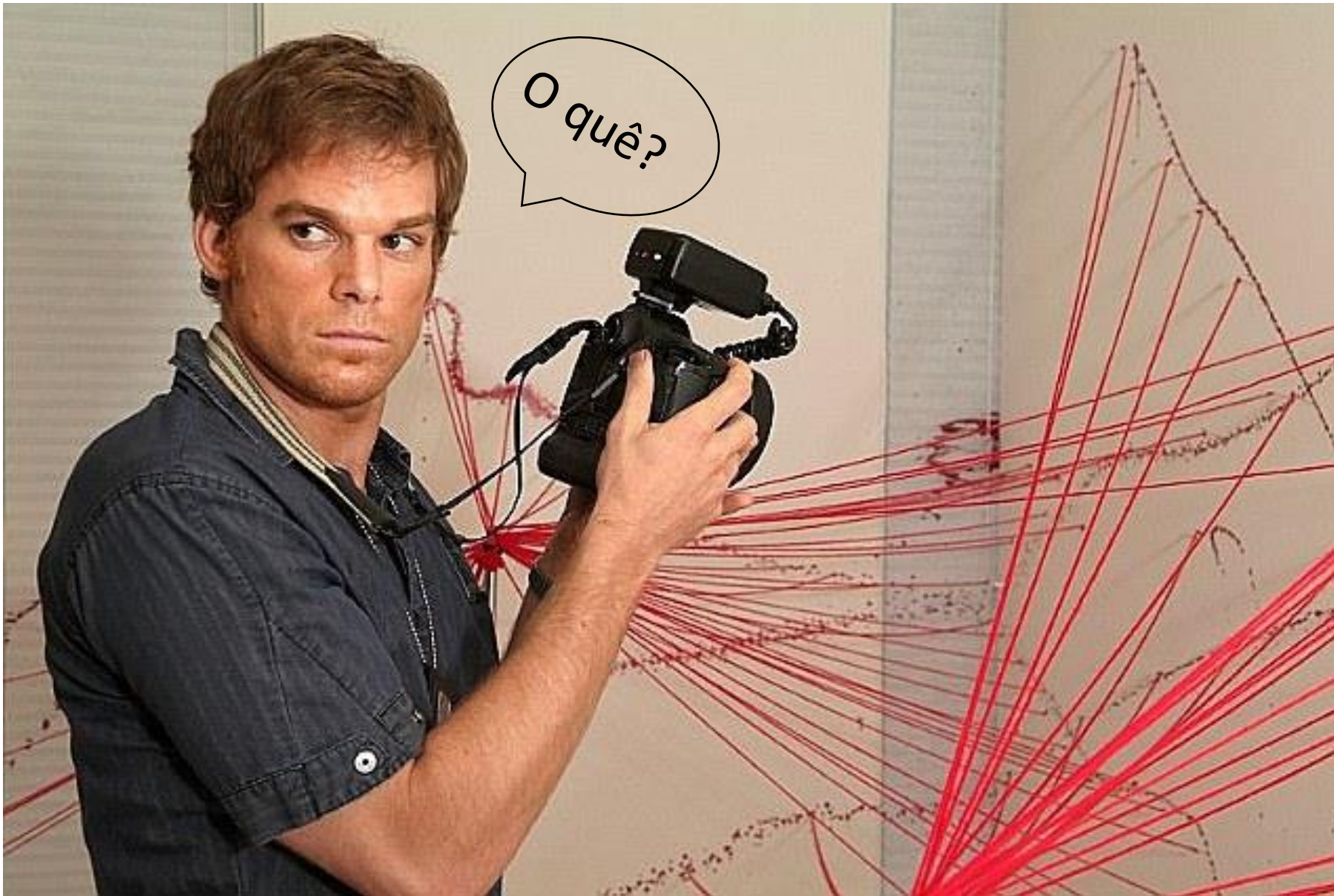


O Modelo Teórico



$$\alpha = \sin^{-1} \left(\frac{\text{Largura}}{\text{Comprimento}} \right) = \sin^{-1} \left(\frac{\overline{LM}}{\overline{JK}} \right)$$



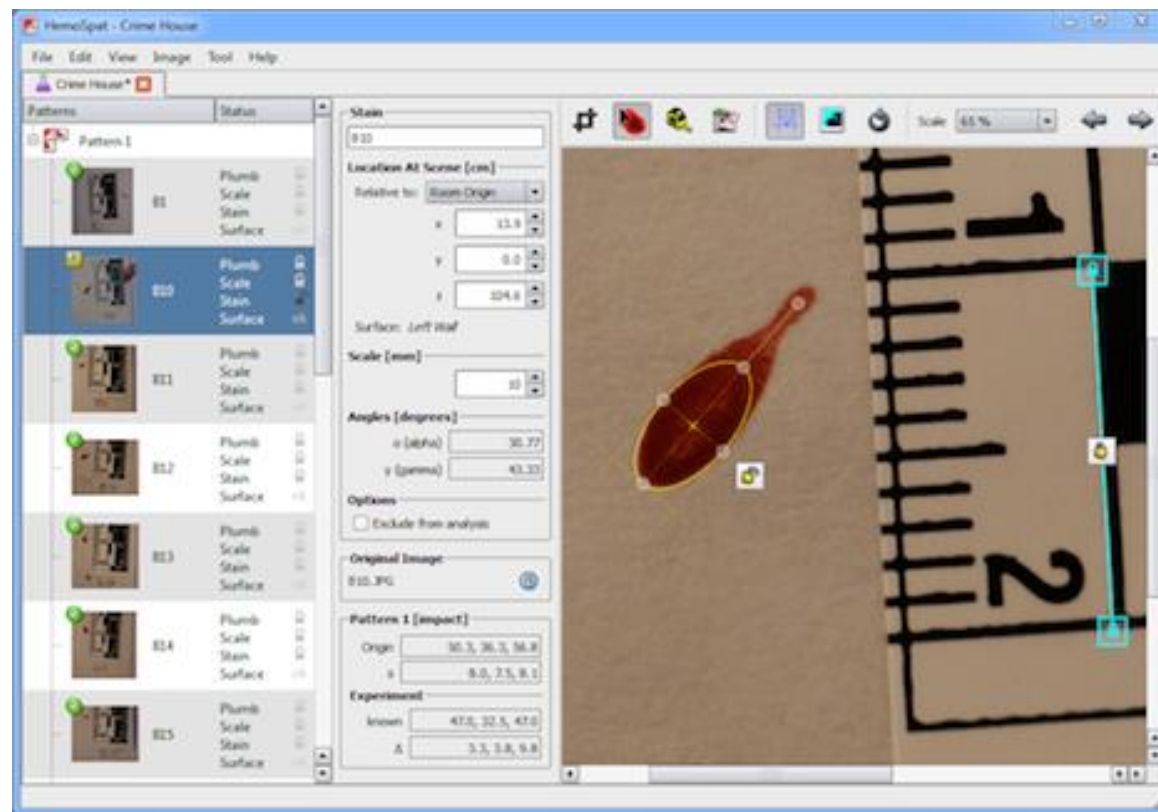


Produtos Comerciais

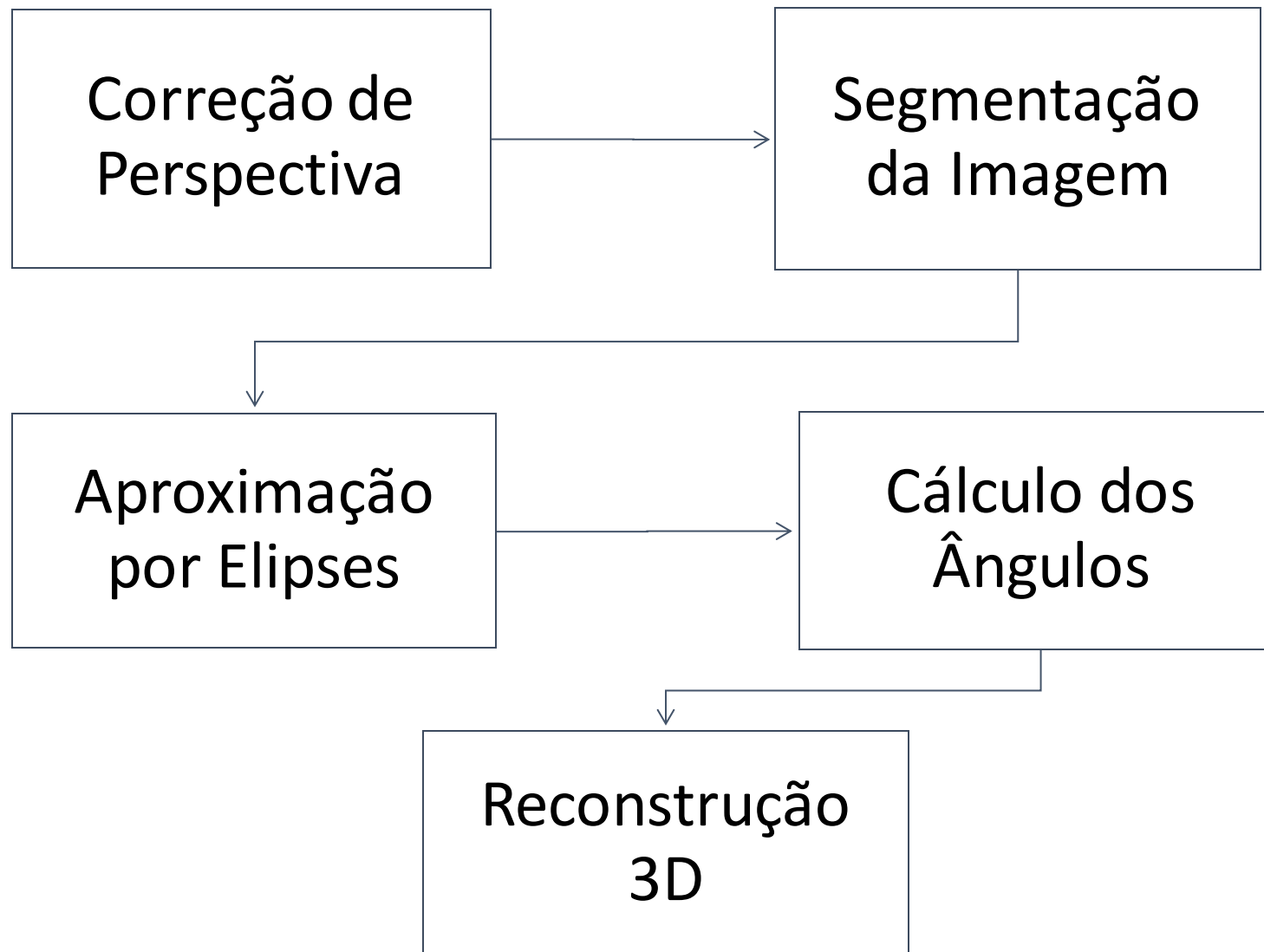


www.hemospat.com

License: USD \$ 1499 per user



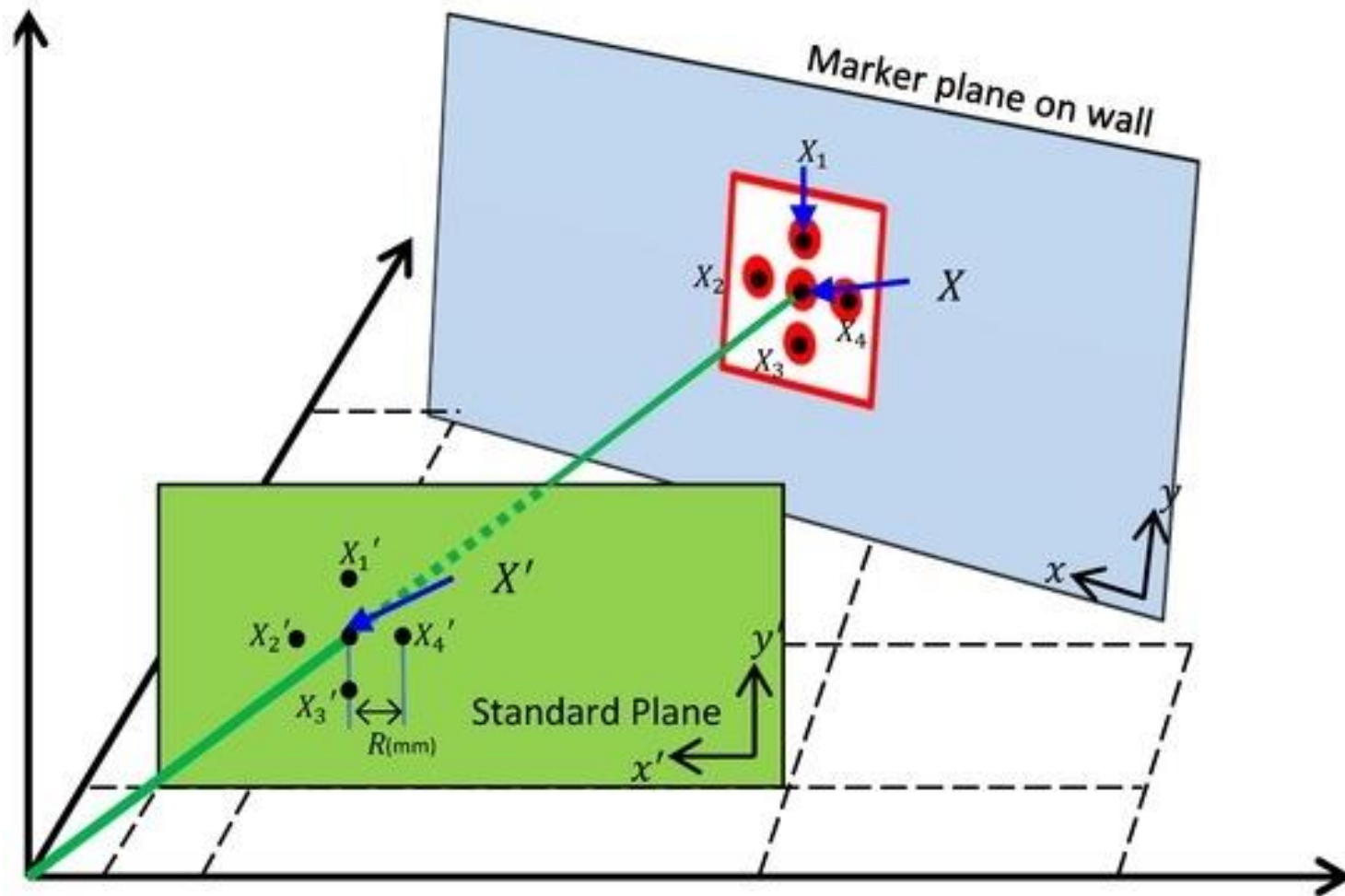
Fluxo de Processamento



Correção de Perspectiva



Correção de Perspectiva



Correção de Perspectiva

Algoritmo DLT

$$\mathbf{x}'_i = \mathbf{H} \mathbf{x}_i$$

$$\begin{bmatrix} x'_i \\ y'_i \\ 1 \end{bmatrix} = \begin{bmatrix} h_{11} & h_{12} & h_{13} \\ h_{21} & h_{22} & h_{23} \\ h_{31} & h_{32} & h_{33} \end{bmatrix} \begin{bmatrix} x_i \\ y_i \\ 1 \end{bmatrix}$$

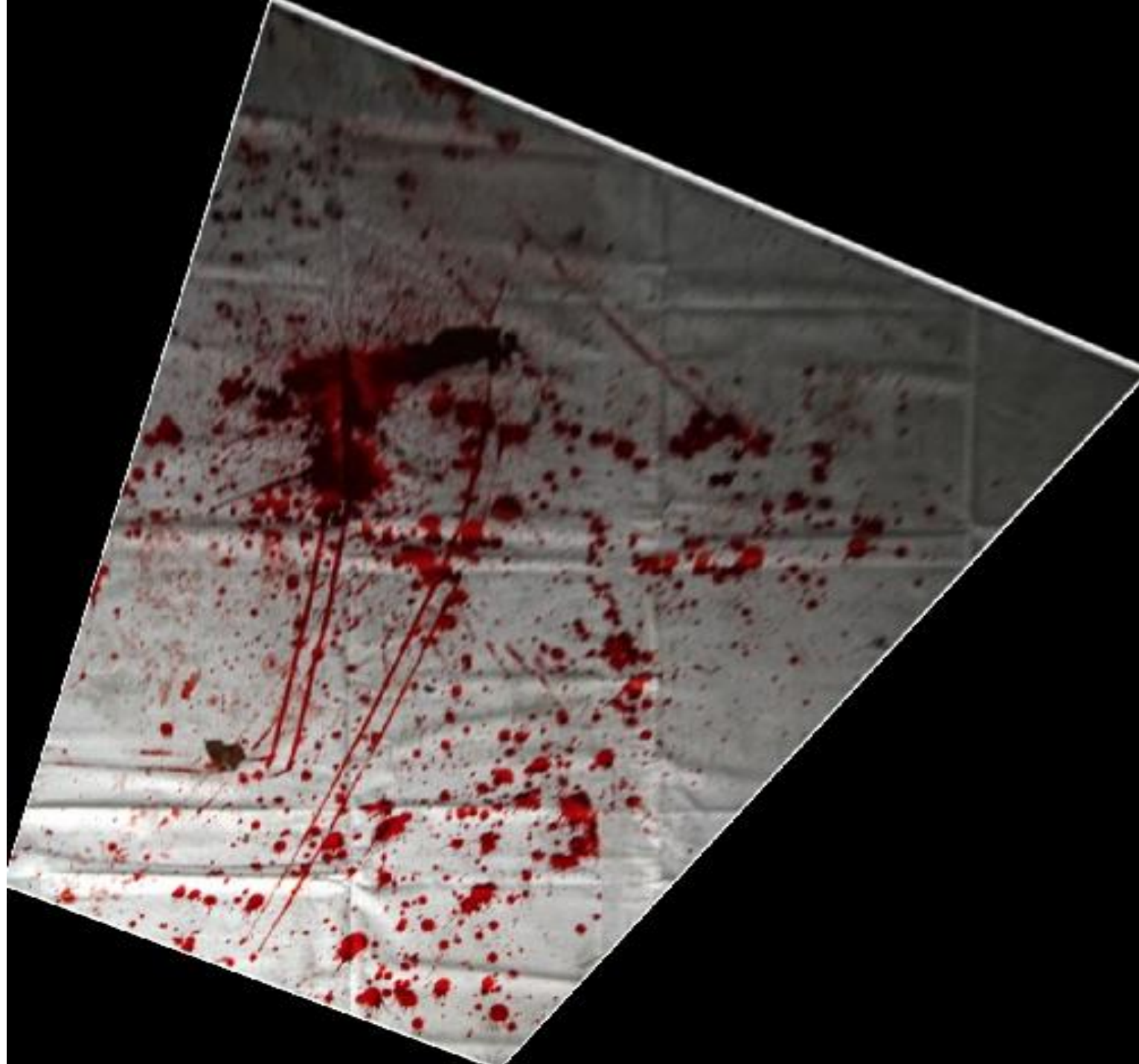
$$\mathbf{x}'_i \times \mathbf{H} \mathbf{x}_i = 0$$

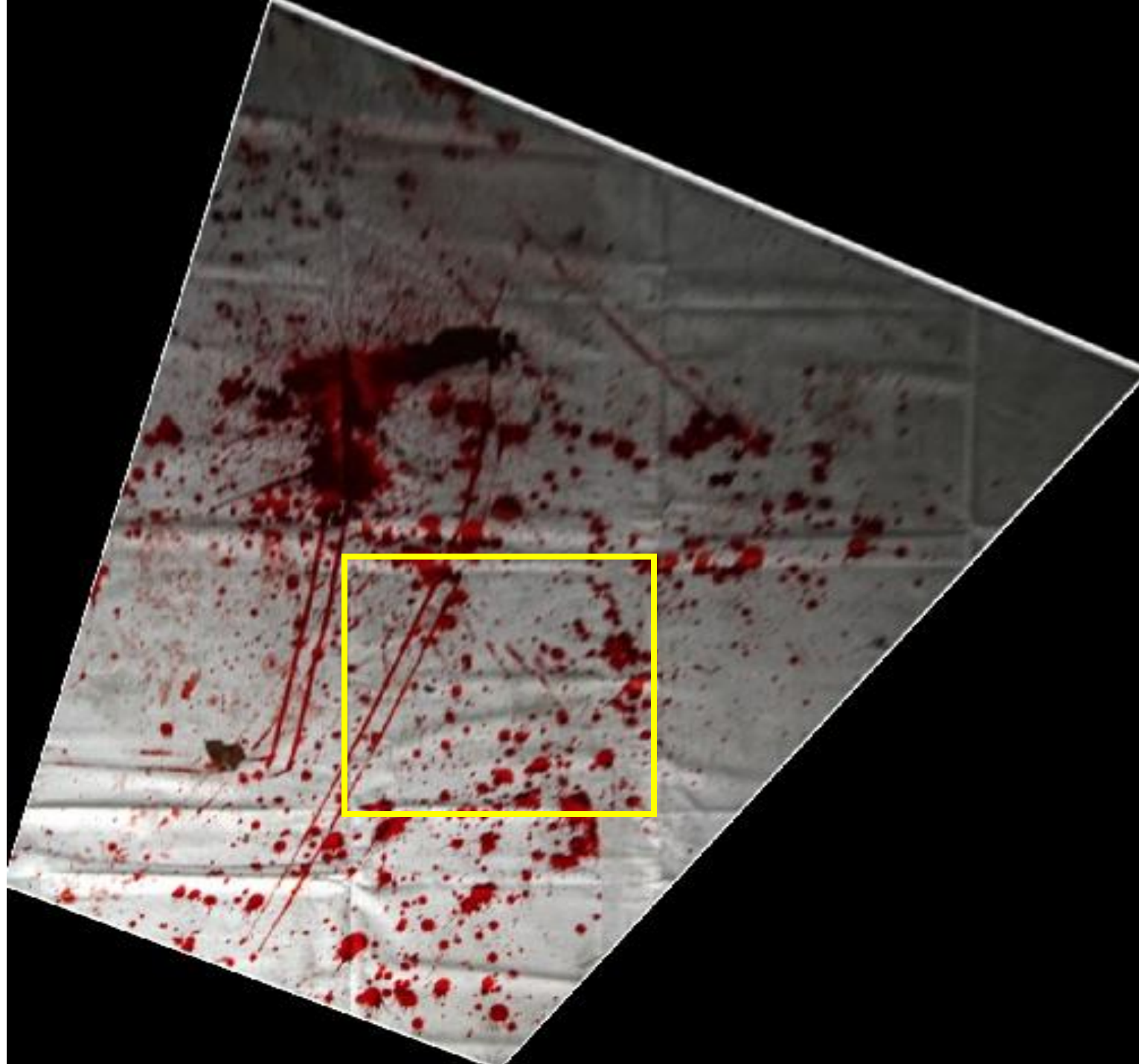
$$\begin{bmatrix} x'_i \\ y'_i \\ 1 \end{bmatrix} \times \begin{bmatrix} \mathbf{h}_1^T \mathbf{x}_i \\ \mathbf{h}_2^T \mathbf{x}_i \\ \mathbf{h}_3^T \mathbf{x}_i \end{bmatrix} = \begin{bmatrix} y'_i \mathbf{h}_3^T \mathbf{x}_i - \mathbf{h}_2^T \mathbf{x}_i \\ \mathbf{h}_1^T \mathbf{x}_i - x'_i \mathbf{h}_3^T \mathbf{x}_i \\ x'_i \mathbf{h}_2^T \mathbf{x}_i - y'_i \mathbf{h}_1^T \mathbf{x}_i \end{bmatrix} \begin{bmatrix} 0^T & -\mathbf{x}_i^T & y'_i \mathbf{x}_i^T \\ \mathbf{x}_i^T & 0^T & -x'_i \mathbf{x}_i^T \\ -y'_i \mathbf{x}_i^T & x'_i \mathbf{x}_i^T & 0^T \end{bmatrix} \begin{pmatrix} \mathbf{h}_1 \\ \mathbf{h}_2 \\ \mathbf{h}_3 \end{pmatrix} = 0$$

view pattern 10x7 (20 mm x 20 mm)

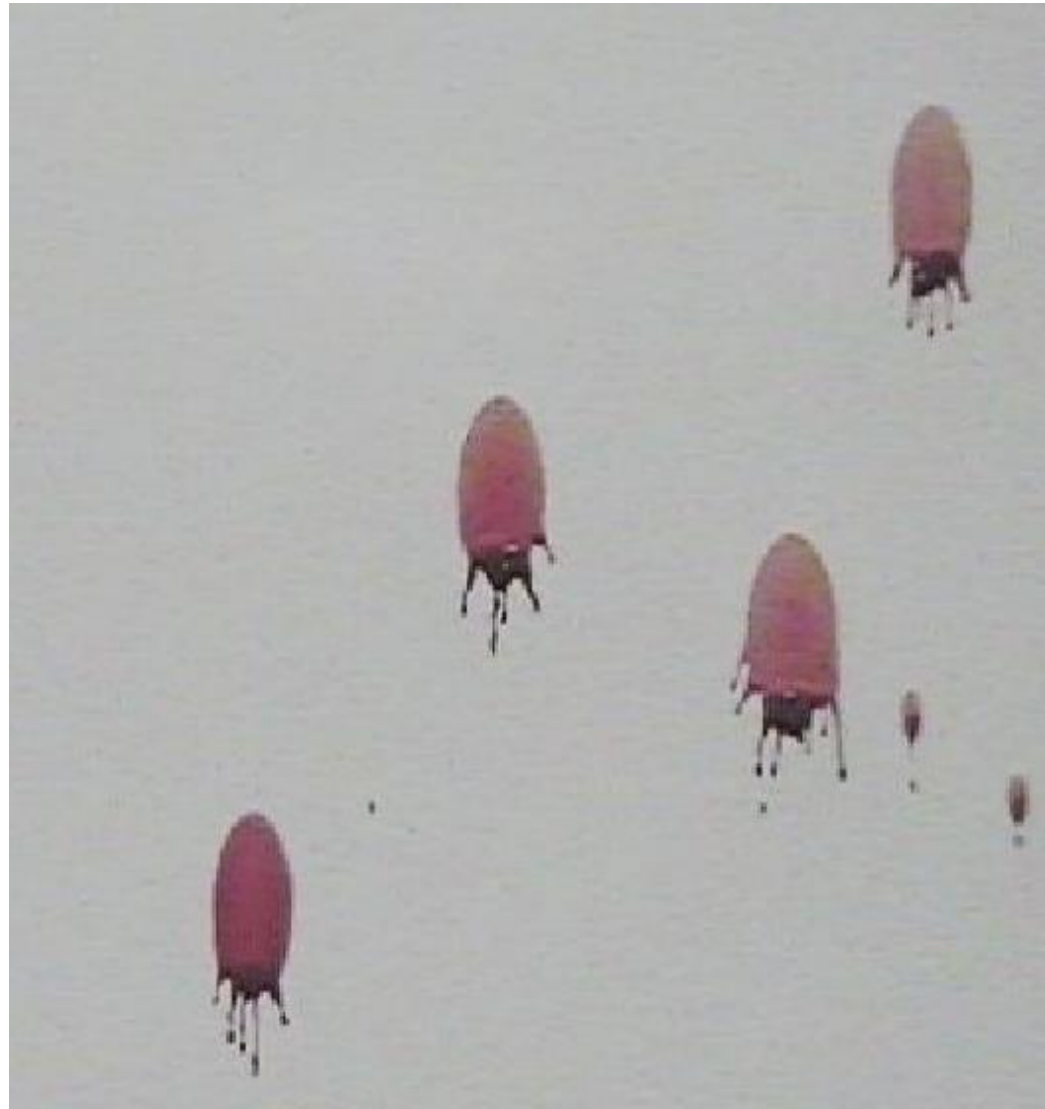






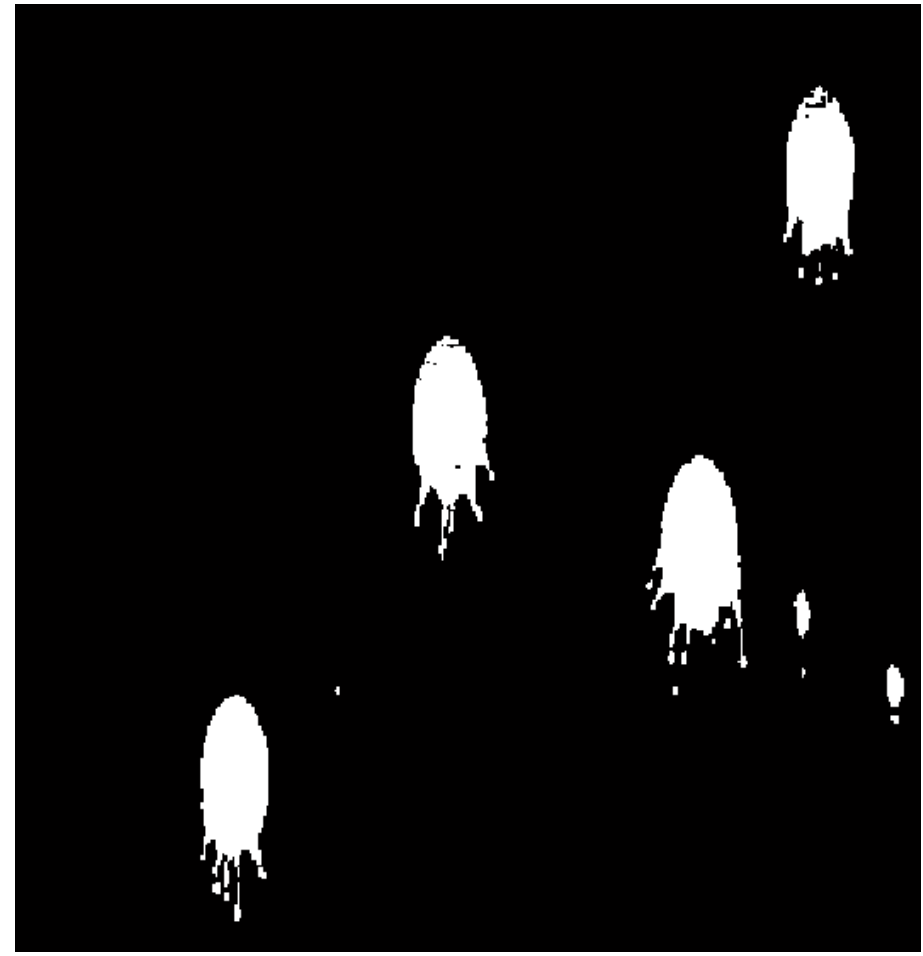


Segmentação da Imagem

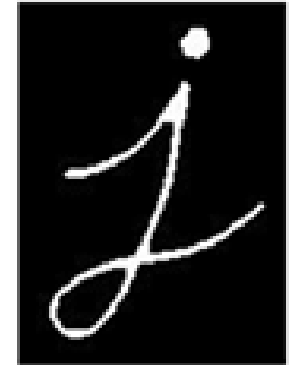
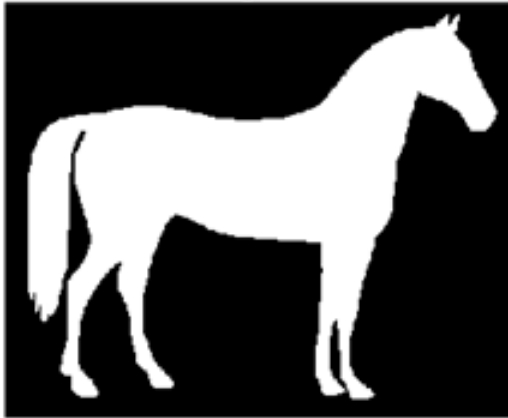


Binarização da Imagem

Algoritmo de Threshold Adaptativo



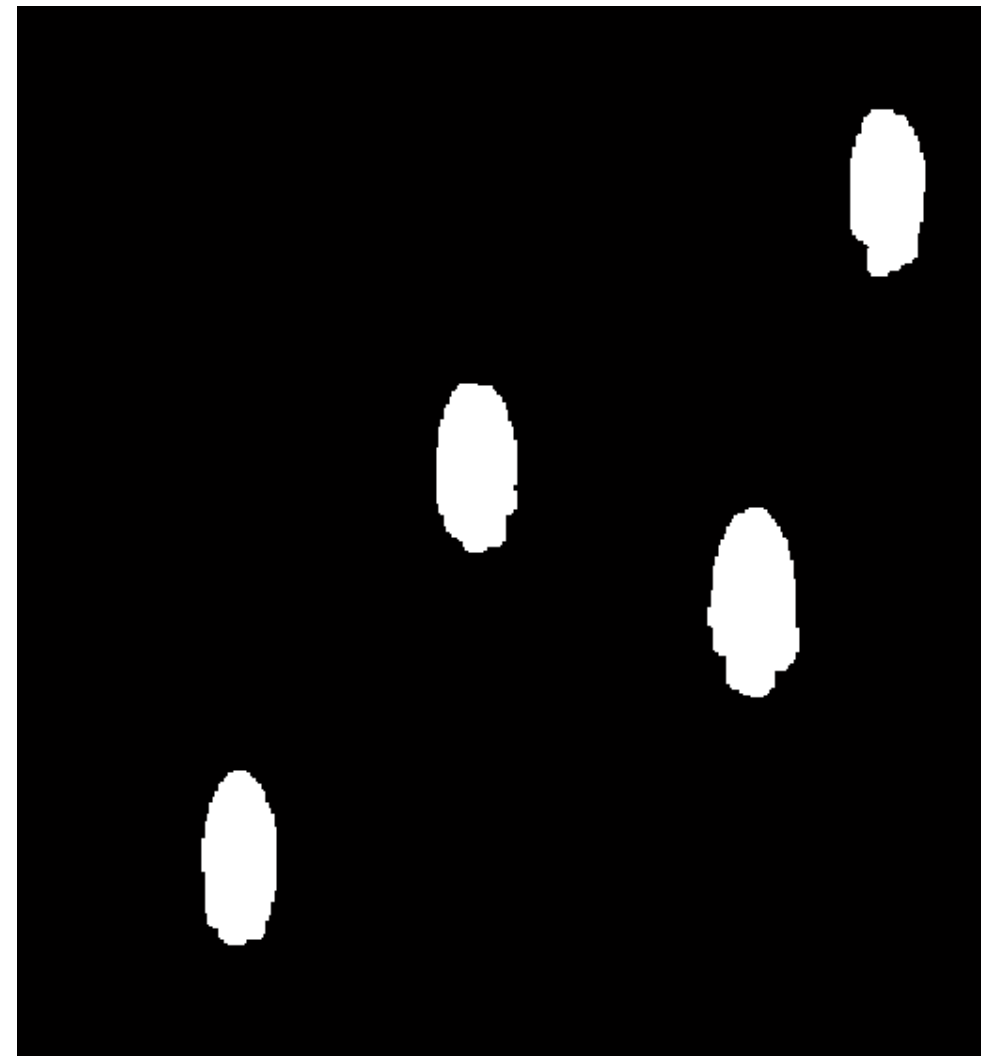
Processamento Morfológico das Imagens



Operação Flood Fill

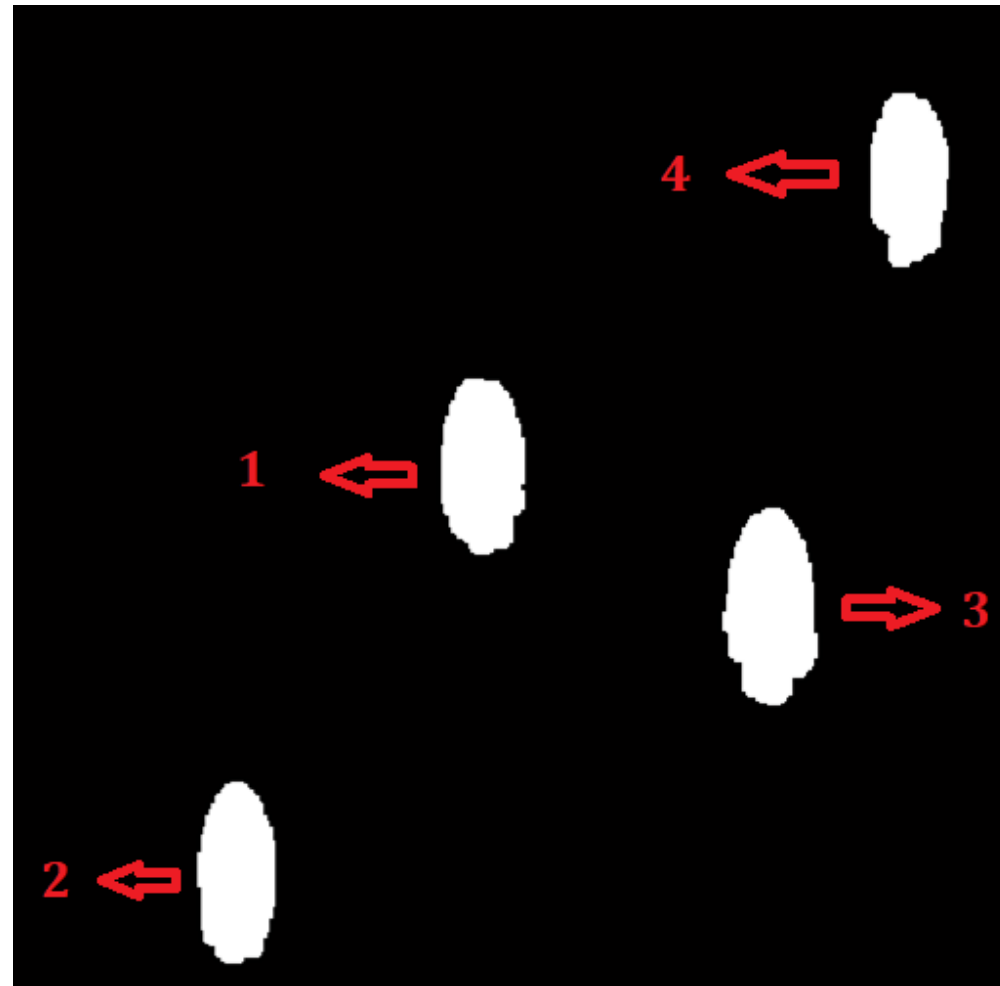


Operação Opening

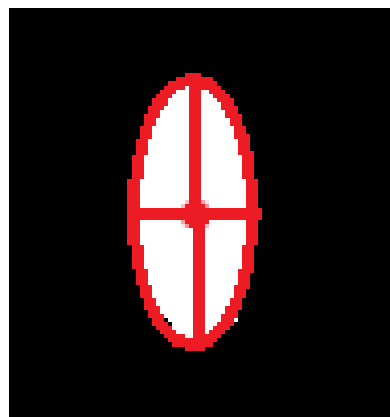
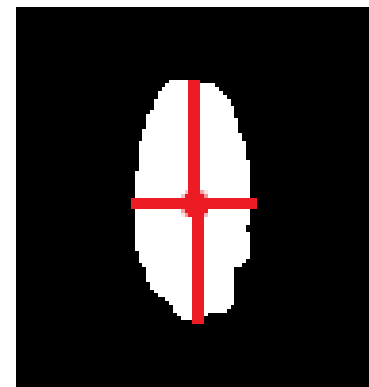
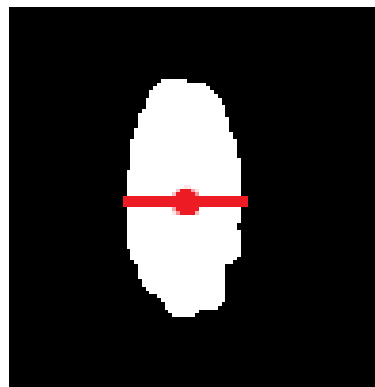
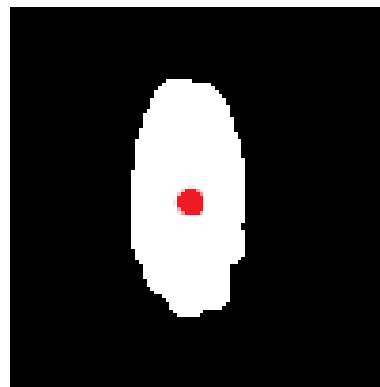


Rotulação de Regiões

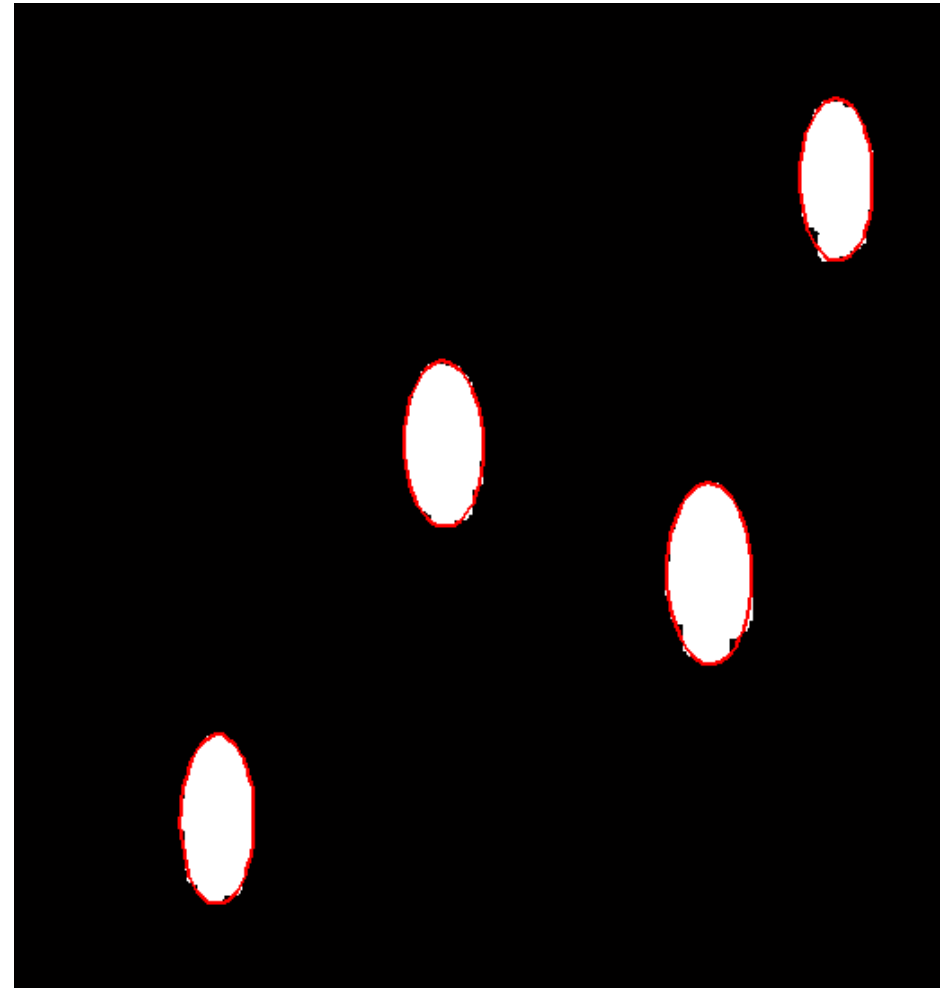
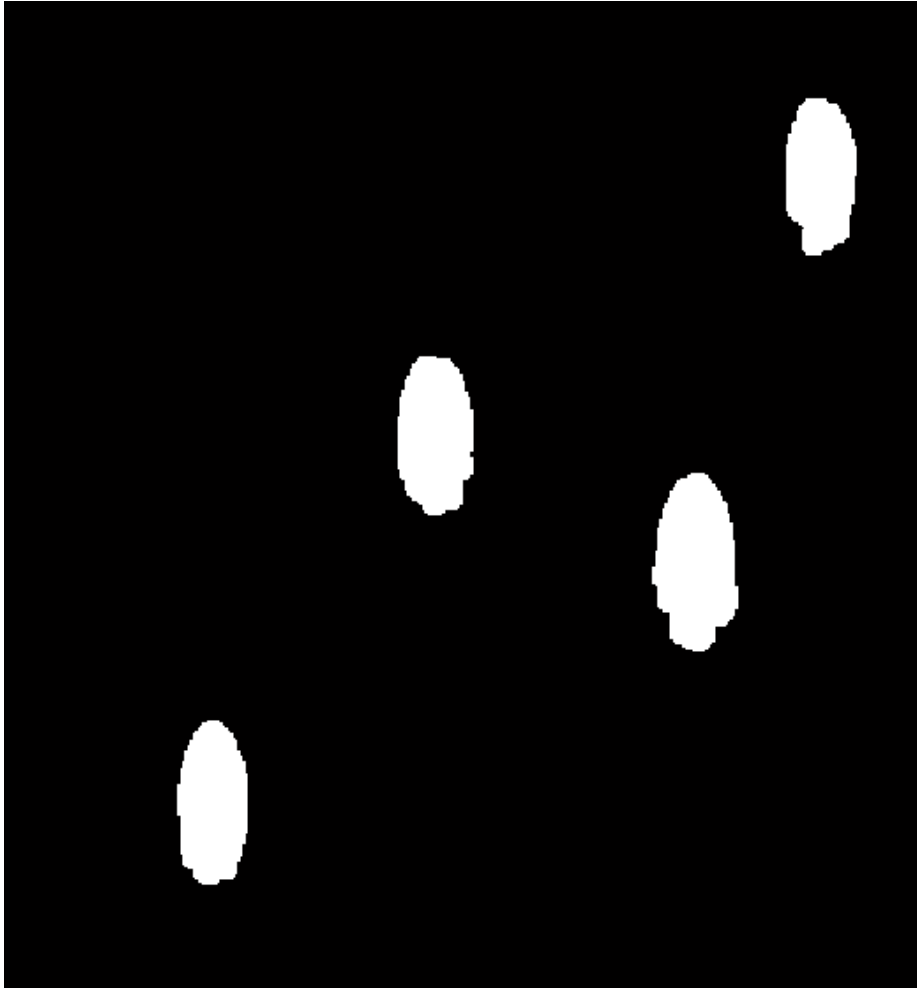
Run Length Encoding Algorithm



Aproximação por Elipses



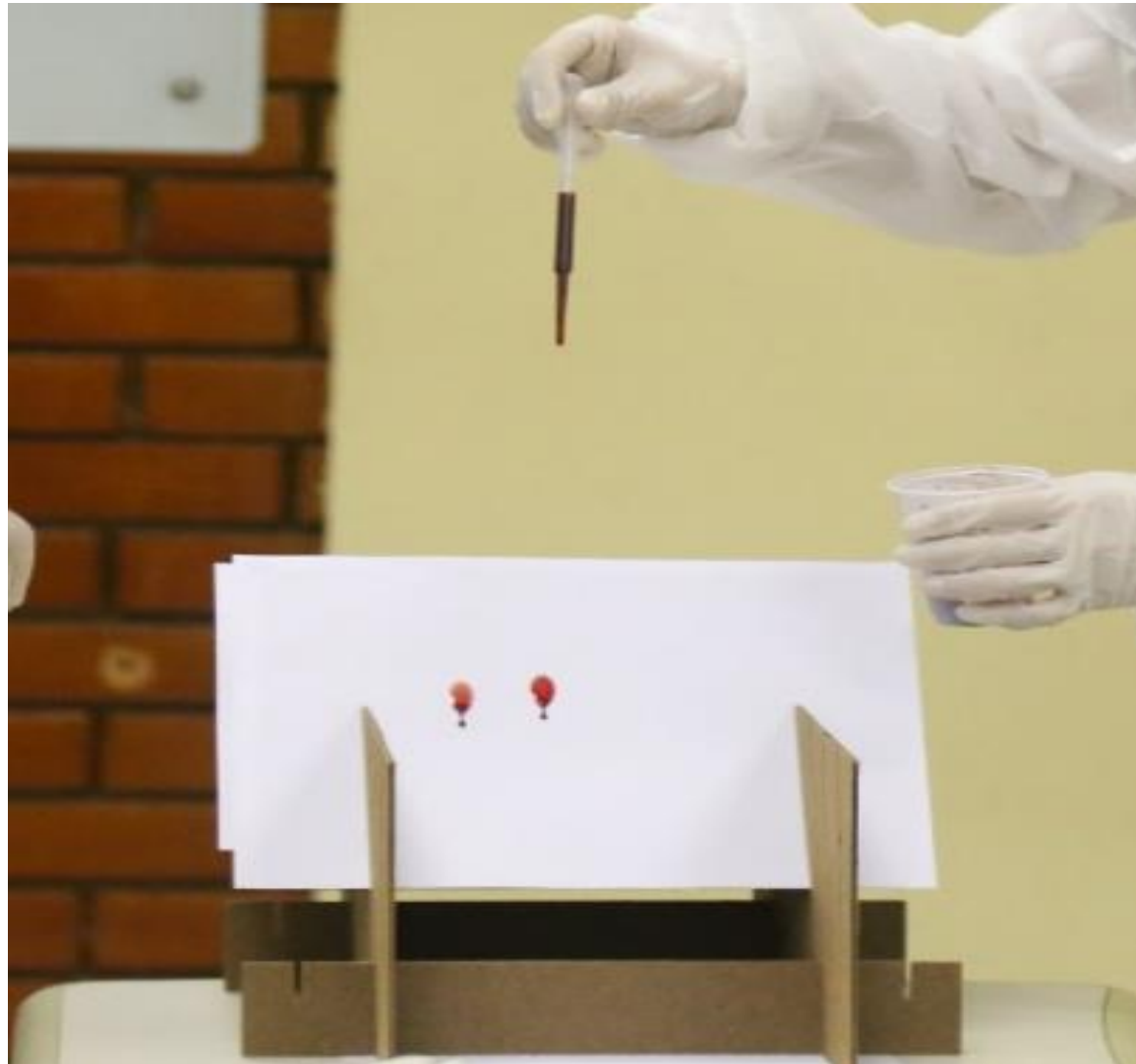
Ellipses Fitting and Angles Calculations



Ângulos de Impacto



Arranjo Experimental



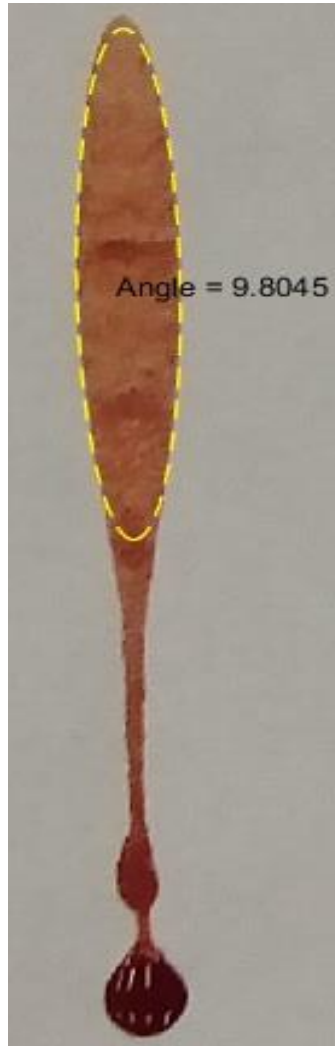
Método Tradicional



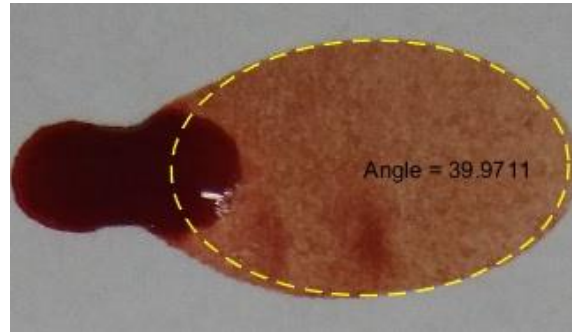
$$\alpha = \sin^{-1} \left(\frac{\textit{Largura}}{\textit{Comprimento}} \right)$$

Ângulo conhecido de 10°
Resultado: $10,47^\circ$

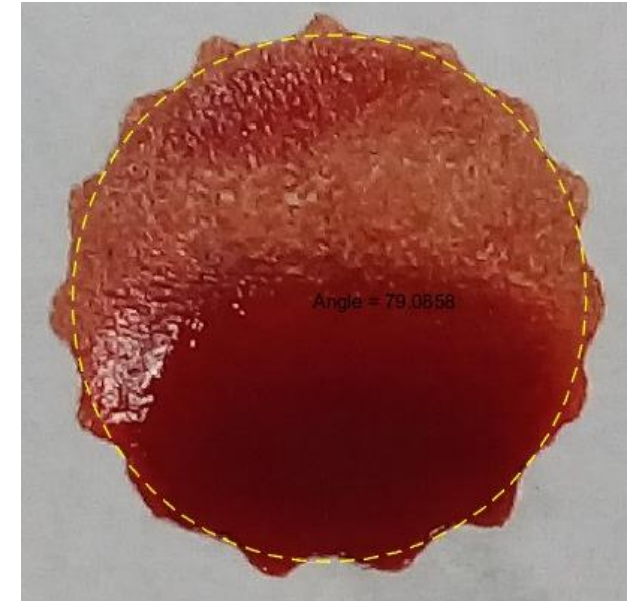
Método Software



Ângulo conhecido de 10°
Resultado: $9,80^\circ$



Ângulo conhecido de 40°
Resultado: $39,97^\circ$



Ângulo conhecido de 80°
Resultado: $79,08^\circ$

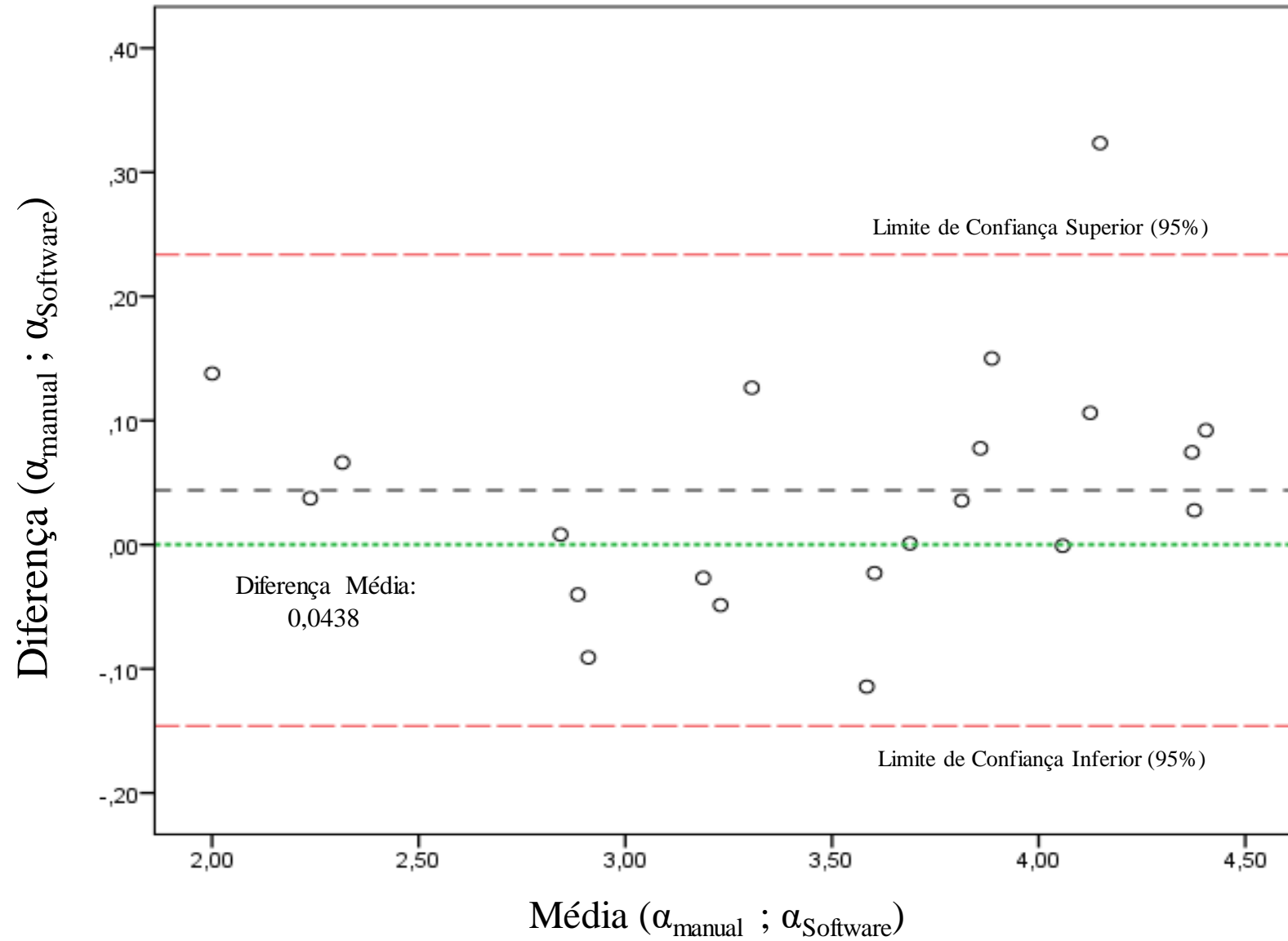
Resultados - Comparação

α experimento	Espargimento 1		Espargimento 2		Espargimento 3	
	α manual	α software	α manual	α software	α manual	α software
10°	10,47°	9,80°	9,55°	9,20°	7,92°	6,90°
20°	17,55°	18,27°	17,24°	17,10°	17,55°	19,22°
30°	24,68°	25,91°	23,93°	24,58°	29,06°	25,61°
40°	40,01°	39,97°	36,29°	37,13°	34,02°	38,14°
50°	46,14°	44,53°	52,55°	45,23°	49,29°	45,61°
60°	74,46°	53,88°	65,23°	58,66°	57,83°	57,88°
80°	82,12°	76,23°	85,68°	78,14°	80,68°	78,48°

Resultados - Comparação

α experimento	Erro - experimento x manual			Erro - experimento x software		
	Esparg. 1	Esparg. 2	Esparg. 3	Esparg. 1	Esparg. 2	Esparg. 3
10	4,46% (+)	4,73%	26,20%	1,99%	8,74%	44,88%
20	13,98%	15,99%	13,98%	9,48%	16,95%	4,06%
30	21,54%	25,36%	3,24%	15,77%	22,06%	17,13%
40	0,03% (+)	10,22%	17,59%	0,07%	7,72%	4,86%
50	8,36%	4,86% (+)	1,45%	12,28%	10,54%	9,62%
60	19,42% (+)	8,02% (+)	3,75%	11,35%	2,29%	3,67%
80	2,58% (+)	6,63% (+)	0,85% (+)	4,95%	2,37%	1,94%

Comparação Estatística – Bland Altman



Limitações



Limitações



Conclusões

- Rápido
- Completamente automático
- Resultado igual ao método tradicional em termos de precisão
- Todos os parâmetros envolvidos podem ser ajustados

Obrigado!

costadias.victorhugo@gmail.com



**POLÍCIA CIVIL
DO DISTRITO FEDERAL**



UnB



C A P E S