

Modelos Ocultos de Markov

HMM



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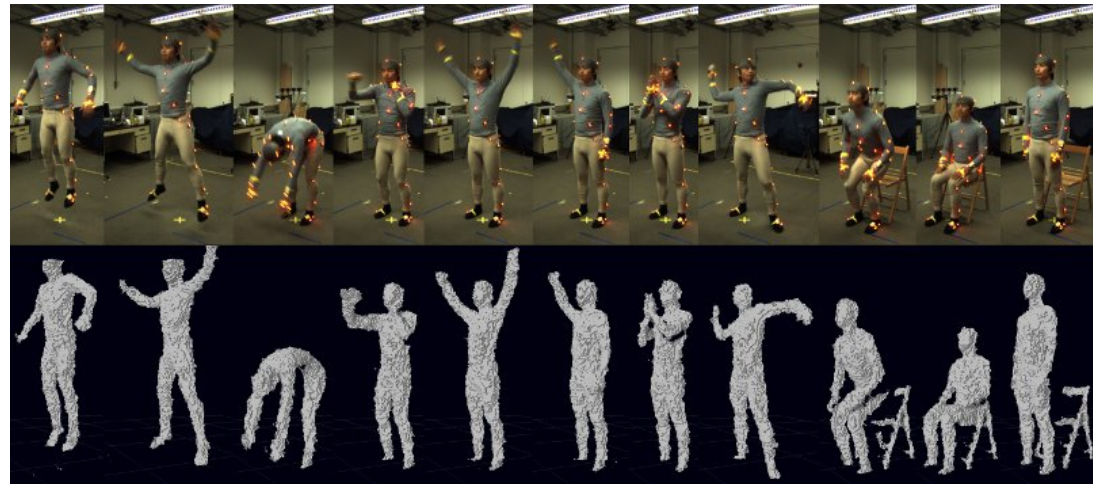
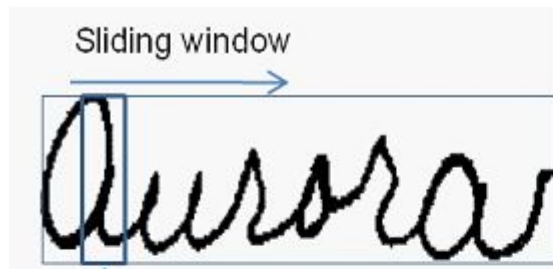
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Contenido

1. Preguntas iniciales
2. Sequential Learning
3. Modelo HMM: Concepto
4. Modelo HMM: Análisis matemático
5. Ejemplo de uso: Reconocimiento de Acciones
6. Modelos avanzados de Sequential Learning

Preguntas iniciales

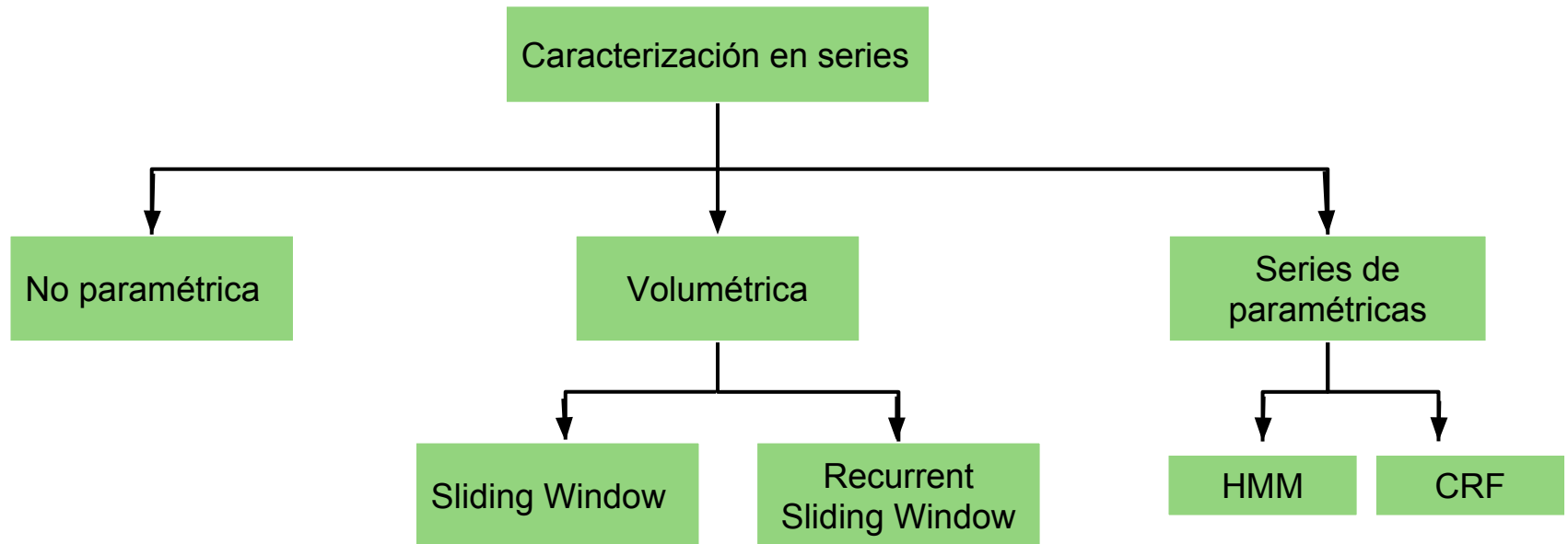
¿Como modelar datos que cambian a través del tiempo, espacio, frecuencia, etc?



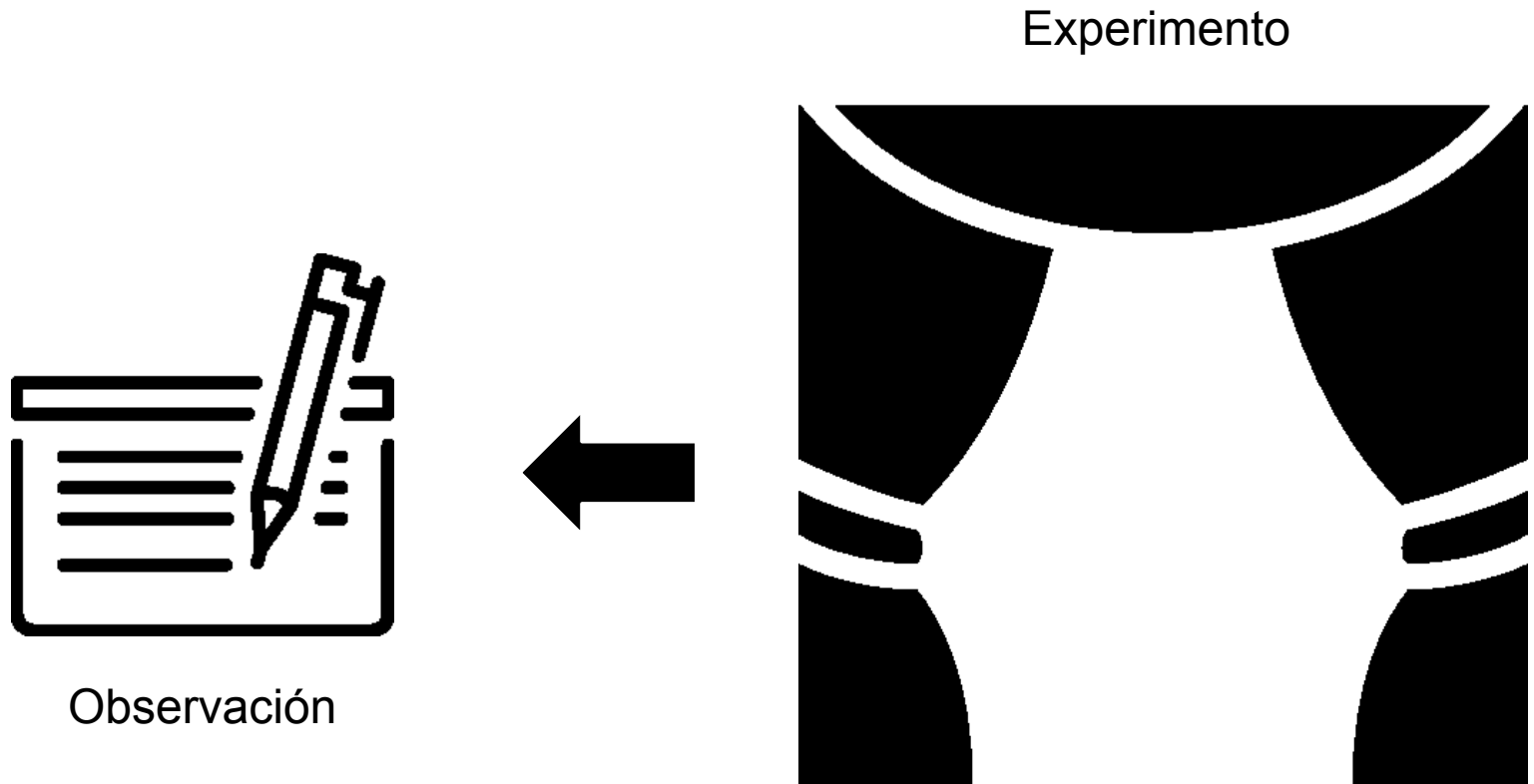
<http://www.intechopen.com/books/advances-in-character-recognition/online-handwritten-chinese-japanese-character-recognition>

http://tele-immersion.citris-uc.org/berkeley_mhad

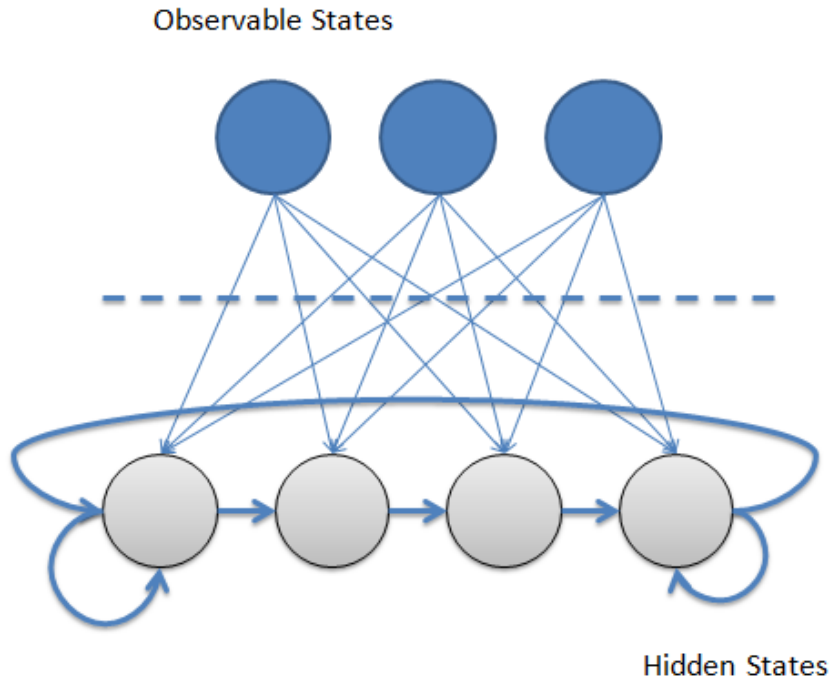
Sequential Learning



Modelo HMM: Concepto



Modelo HMM: Análisis Matemático



<http://crsouza.com/2010/03/hidden-markov-models-in-c/>

Definido por 2 distribuciones

$$p(y_t|y_{t-1}) \quad (1)$$

$$p(x_t|y_t) \quad (2)$$

Distribución conjunta

$$P(y, x) = \prod_{t=1}^T p(y_t|y_{t-1})p(x_t|y_t)$$

Modelo HMM: Observaciones

Entrenamiento:

Algoritmo Forward - Backward

Parámetros: Tamaño ventana y Estados

Formas de uso:

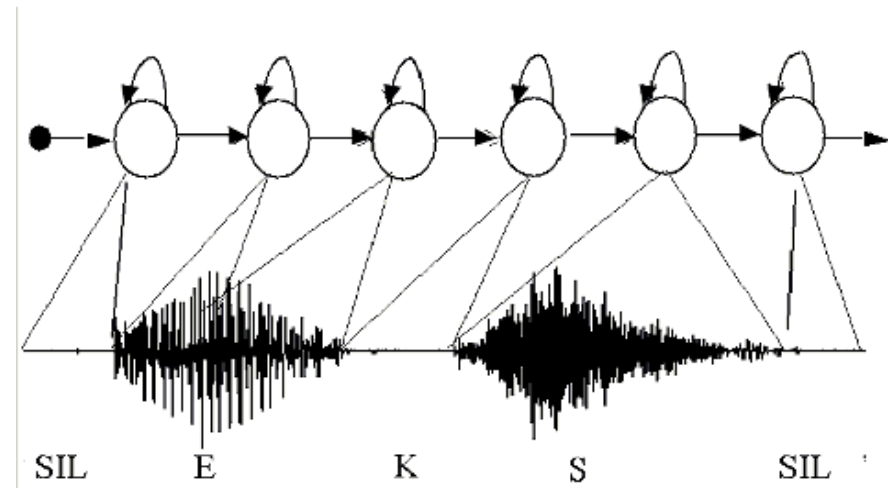
1. Clasificación de secuencia completa
2. Predicción de secuencia (Viterbi decode)

Problemas identificados:

1. Poca influencia de condición Markoviana
2. Un dato por observación, no hay influencia

Modificaciones propuestas:

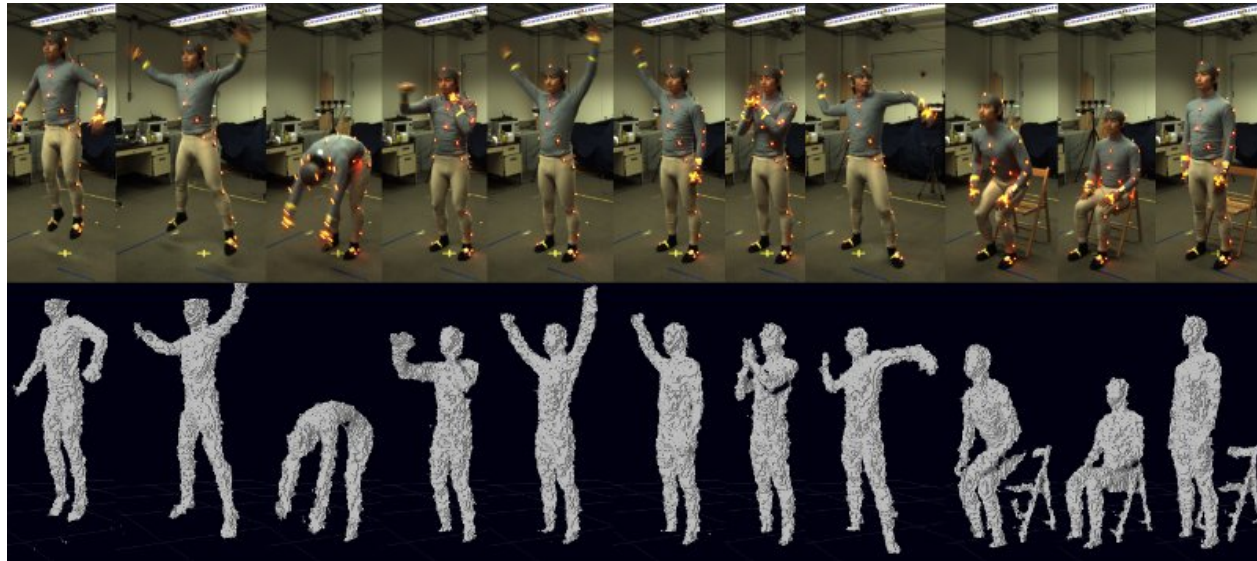
1. Maximum Entropy Markov Models(MEMM)
2. Input - output hidden Markov models(IOHMM)



<https://www.uea.ac.uk/documents/429378/431923/Research+Speech+Group.gif/a034bc65-737c-4fce-ab81-80235b8dd454?t=1346659120920>

Ejemplo

Reconocimiento de acciones en video



Codigo disponible en:

https://github.com/alviur/Action_recognition

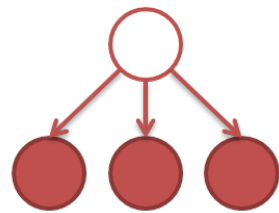
Ejemplo: Resultados



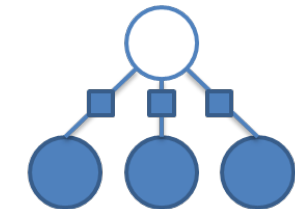
Ergodic Architecture

States	Mixtures	Jump	Sit down	Stand up	Total
3	2	100% \pm 0	100% \pm 0	96,67% \pm 0,0703	98,89% \pm 0,0234
	3	91,67% \pm 0,2115	98,33% \pm 0,0527	98,33% \pm 0,0527	96,04% \pm 0,0698
	4	100% \pm 0	95% \pm 0,1125	100% \pm 0	98,33% \pm 0,0375
	5	100% \pm 0	100% \pm 0	98,33% \pm 0,0527	99,44% \pm 0,0176
	6	100% \pm 0	95% \pm 0,1581	96,67% \pm 0,1054	97,22% \pm 0,06
	2	100% \pm 0	98,33% \pm 0,0527	100% \pm 0	99,44% \pm 0,0176
4	3	100% \pm 0	81,67% \pm 0,3465	98,33% \pm 0,0527	93,33% \pm 0,1136
	4	100% \pm 0	78,67% \pm 0,3713	96,67% \pm 0,1054	91,94% \pm 0,1189
	5	100% \pm 0	100% \pm 0	95% \pm 0,1581	98,33% \pm 0,0527
	6	100% \pm 0	85,67% \pm 0,3071	98,33% \pm 0,0527	94,79% \pm 0,099
	2	100% \pm 0	90% \pm 0,3162	96,67% \pm 0,0703	95,56% \pm 0,1041
	3	100% \pm 0	98,33% \pm 0,0527	100% \pm 0	99,44% \pm 0,0176
5	4	100% \pm 0	98,33% \pm 0,0527	98,33% \pm 0,0527	98,89% \pm 0,0234
	5	100% \pm 0	100% \pm 0	95% \pm 0,0805	98,33% \pm 0,0268
	6	100% \pm 0	88,33% \pm 0,3148	98,33% \pm 0,0527	95,56% \pm 0,1041

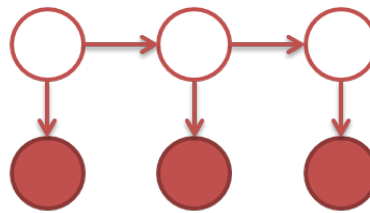
Modelos Avanzados



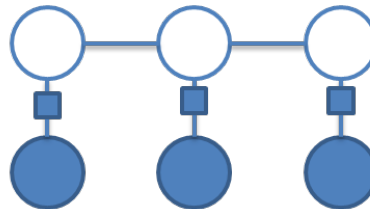
Naïve Bayes



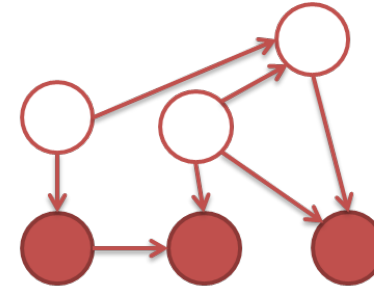
Logistic Regression



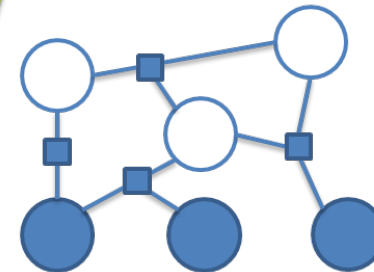
Markov models



Linear-chain CRF



Directional Models



CRF

Sequences

Graphs

Generative

Discriminative

Adapted from C. Sutton, A. McCallum, "An Introduction to Conditional Random Fields", ArXiv, November 2010

Modelos Avanzados Resultados

HMM

States	Mixtures	Jump	Sit down	Stand up	Jack	Punch	Sit down - Stand up	Total
3	2	100 \pm 0	98,33 \pm 5,27	100 \pm 0	90 \pm 31,62	98,33 \pm 5,27	0 \pm 0	81,01 \pm 6,08
	3	100 \pm 0	93,33 \pm 16,1	88,33 \pm 24,91	90 \pm 31,62	98,33 \pm 5,27	10 \pm 31,62	79,9 \pm 4,97
	4	98,33 \pm 5,27	95 \pm 15,81	93,33 \pm 16,1	90 \pm 31,62	100 \pm 0	40 \pm 51,64	86,01 \pm 7,45
	5	98,33 \pm 5,27	100 \pm 0	98,33 \pm 5,27	90 \pm 31,62	100 \pm 0	30 \pm 48,3	86,01 \pm 7,45
	6	100 \pm 0	93,33 \pm 21,08	96,67 \pm 7,03	88,33 \pm 31,48	100 \pm 0	50 \pm 52,7	87,96 \pm 8,04
4	2	100 \pm 0	98,33 \pm 5,27	100 \pm 0	90 \pm 31,62	100 \pm 0	0 \pm 0	81,29 \pm 5,21
	3	100 \pm 0	96,67 \pm 7,03	81,67 \pm 38,85	90 \pm 31,62	98,33 \pm 5,27	30 \pm 48,3	82,68 \pm 7,94
	4	100 \pm 0	81,67 \pm 30,88	100 \pm 0	80 \pm 42,16	100 \pm 0	60 \pm 51,64	86,85 \pm 7,36
	5	96,67 \pm 10,54	96,67 \pm 7,03	100 \pm 0	90 \pm 31,62	98,33 \pm 5,27	30 \pm 48,3	85,25 \pm 6,5
	6	100 \pm 0	98,33 \pm 5,27	91,67 \pm 18	88,33 \pm 31,48	98,33 \pm 5,27	40 \pm 51,64	86,11 \pm 6,8
5	2	100 \pm 0	100 \pm 0	100 \pm 0	90 \pm 31,62	98,33 \pm 5,27	0 \pm 0	81,29 \pm 6,12
	3	96,67 \pm 10,54	100 \pm 0	90,67 \pm 20,66	90 \pm 31,62	98,33 \pm 5,27	5 \pm 52,7	87,7 \pm 7,46
	4	100 \pm 0	100 \pm 0	98,33 \pm 5,27	88,33 \pm 31,48	98,33 \pm 5,27	30 \pm 48,3	85,74 \pm 7,62
	5	96,67 \pm 10,54	98,33 \pm 5,27	98,33 \pm 5,27	88,33 \pm 31,48	100 \pm 0	40 \pm 51,64	86,85 \pm 7,36
	6	71,19 \pm 19,3	92,32 \pm 13,52	75,89 \pm 30,34	90 \pm 31,62	100 \pm 0	32,12 \pm 44,02	84,35 \pm 7,34

Modelos Avanzados Resultados 2

CRF

Window size	Jump	Sit down	Stand up	Jack	Punch	Sit down - Stand up	Total
0	96,67 ± 7,03	78,33 ± 15,81	69,33 ± 17,48	100 ± 0	90 ± 26,29	81,67 ± 25,4	86 ± 5,99
1	96,67 ± 10,54	86,67 ± 15,32	78,33 ± 19,33	100 ± 0	93,33 ± 21,08	95 ± 15,81	91,62 ± 5,07
2	100 ± 0	86,67 ± 15,32	79,67 ± 17,17	100 ± 0	100 ± 0	100 ± 0	94,43 ± 3,92
3	98,33 ± 5,27	81,67 ± 21,44	76 ± 21,53	100 ± 0	96,67 ± 10,54	96,67 ± 10,54	91,6 ± 3
4	96,67 ± 7,03	86,67 ± 15,32	78 ± 13,63	100 ± 0	100 ± 0	93,33 ± 21,08	92,42 ± 4,09
5	96,67 ± 7,03	85 ± 18,34	86 ± 12,05	100 ± 0	100 ± 0	96,67 ± 10,54	94,1 ± 3,19
6	96,67 ± 7,03	90 ± 11,65	84,33 ± 17,5	100 ± 0	96,67 ± 10,54	96,67 ± 10,54	94,1 ± 4,52

Modelos Avanzados Resultados 3

HCRF

States	Window size	Jump	Sit down	Stand up	Jack	Punch	Sit down - Stand up	Total
2	0	90 ± 11,65	90 ± 17,92	93,33 ± 11,65	83,33 ± 31,43	86,67 ± 21,94	96,67 ± 7,03	90% ± 7,88
	1	83,33 ± 26,06	91,67 ± 8,78	93,33 ± 14,05	90 ± 16,1	83,33 ± 20,79	85 ± 22,84	87,71 ± 9,9
	2	83,33 ± 19,25	91,67 ± 14,16	77 ± 28,87	91,67 ± 11,79	76,67 ± 25,09	90 ± 14,05	85,02 ± 10
	3	78,33 ± 26,12	91 ± 13,43	84,67 ± 12,39	90 ± 14,05	93,33 ± 21,08	81,67 ± 24,15	86,57 ± 11,95
3	0	90 ± 26,29	88,33 ± 22,29	98,33 ± 5,27	96,67 ± 10,54	95 ± 11,25	90 ± 14,05	93,02 ± 6,95
	1	93,33 ± 21,08	83,33 ± 30,43	96,67 ± 7,03	100 ± 0	95 ± 11,25	91,67 ± 14,16	93,53 ± 6,13
	2	93,33 ± 11,65	96,67 ± 10,54	96,33 ± 7,77	98,33 ± 5,27	93,33 ± 14,05	95 ± 8,05	95,52 ± 4,39
	3	81,67 ± 18,34	89,67 ± 14,27	86 ± 16,39	93,33 ± 16,1	93,33 ± 11,65	85 ± 19,95	88,24 ± 8,23
4	0	86,67 ± 24,6	91,67 ± 11,79	93,33 ± 14,05	98,33 ± 5,27	100 ± 0	98,33 ± 5,27	94,72 ± 6,47
	1	90 ± 26,29	96,67 ± 7,03	100 ± 0	96,67 ± 10,54	98,33 ± 5,27	93,33 ± 21,08	95,77 ± 6,4
	2	96,67 ± 7,03	98,33 ± 5,27	96,33 ± 7,77	96,67 ± 7,03	98,33 ± 5,27	81,67 ± 27,72	94,62 ± 5,85
	3	93,33 ± 16,1	79,67 ± 23,28	93,33 ± 16,1	95 ± 15,81	90 ± 14,05	93,33 ± 11,65	90,78 ± 8,28
5	0	98,33 ± 5,27	96,67 ± 7,03	91,67 ± 14,16	96,67 ± 10,54	88,33 ± 27,27	93,33 ± 16,1	94,15 ± 6,06
	1	91,67 ± 14,16	96,67 ± 7,03	96,67 ± 7,03	96,67 ± 10,54	91,67 ± 26,35	81,67 ± 22,84	92,43 ± 4,61
	2	98,33 ± 5,27	98,33 ± 5,27	94,67 ± 8,64	100 ± 0	100 ± 0	93,33 ± 11,65	97,48 ± 3,81
	3	98,33 ± 5,27	96,67 ± 7,03	95 ± 11,25	98,33 ± 5,27	98,33 ± 5,27	86,67 ± 29,19	95,47 ± 5,44

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