AMIE: Automatic Monitoring of Indoor Exercises

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Motivation: rehabilitation exercises

Patients with sports-related injuries need to learn correct movement patterns of rehabilitation exercises.

Problem: Feedback from a physiotherapist is limited by visitation frequency.

Research question:
Can we provide automatic feedback using a Kinect camera and Machine Learning?

Problem statement

Given:
A patient performing an exercise

Detect:
1. The type of exercise
2. The correctness of the exercise
3. If the exercise was performed wrong, how exactly?

Data collected with a Microsoft Kinect on 10 subjects

3 exercises

Squat

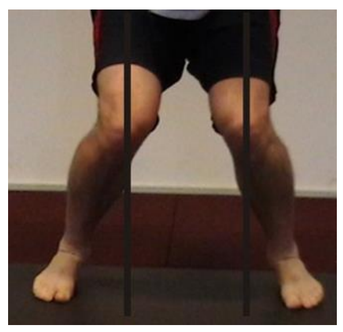
Forward lunge

Side lunge

3 mistake types

Knees over toes (KOT)

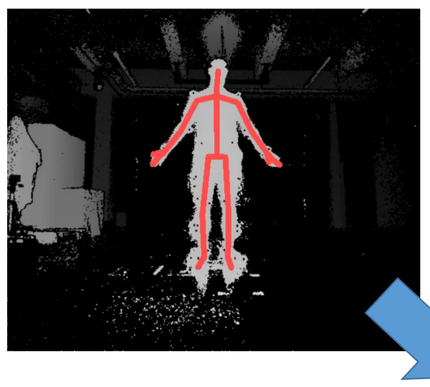
Knock knees (KK)



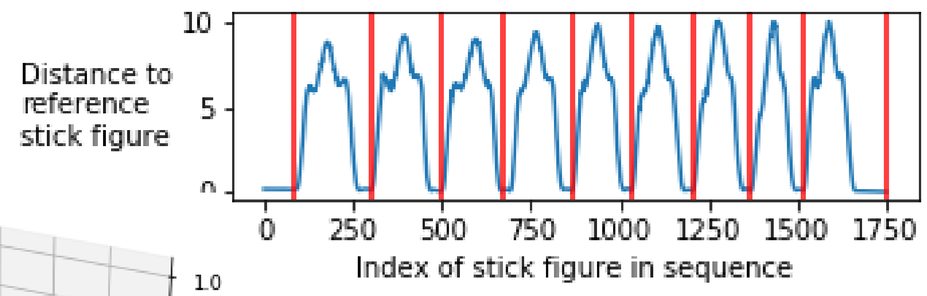
Forward trunk lean (FTL)

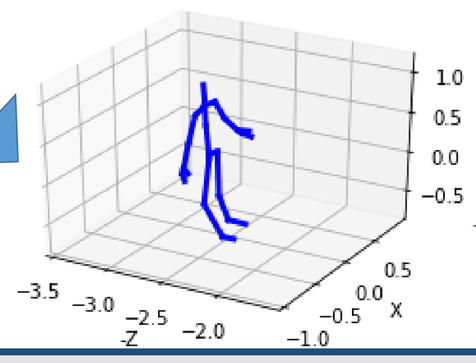
3-step approach to convert Kinect data to feature vectors

1 Extract to Python Dataframes



2 Partition each data stream into individual repetitions





Reference stick figure

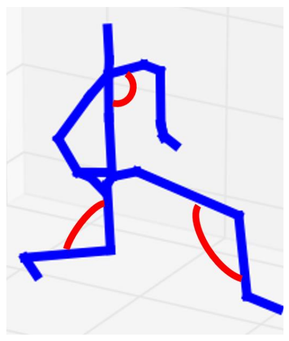
3 Construct feature vector for each repetition

stick figure time series

Transformation #1: compute joint angles

= 30-D angle time series

Transformation #2: compute 5 summary statistics per angle



= 150-length feature vector

Results

We identify exercise type with 99% accuracy and mistake type with 73% accuracy

	Task:	T1		T2		T3	
	Cross-validation setting:	set	subject	set	subject	set	subject
AMIE:	Decision Tree	0.992	0.973	0.731	0.671	0.642	0.555
	Logistic Regression	0.999	0.989	0.772	0.708	0.726	0.672
	Naive Bayes	0.982	0.972	0.633	0.646	0.478	0.547
	Random Forest	0.997	0.987	0.762	0.700	0.705	0.675
	XGBoost	0.997	**0.990**	0.790	**0.734**	**0.741**	**0.738**
Baselines:	NN-DTW (absolute coord.)	**1.000**	0.965	**0.840**	0.623	0.627	0.555
	NN-DTW (angles)	0.997	**0.990**	0.713	0.648	0.576	0.549
	Handcrafted Rule Set	X	X	0.634	0.634	0.590	0.590

We detect FTL mistake better than other mistakes

Predicted / Actual	None	KOT	KK	FTL
None	724	56	66	49
KOT	121	38	28	9
KK	75	10	101	8
FTL	37	3	6	459

Contributions

- Highlight literature shortcoming
- Describe data set and approach in detail
- Data and code available at https://dtai.cs.kuleuven.be/software/amie