



Crowd-based Semantic Event Detection and Video Annotation for Sports Videos

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<firstname.lastname@unibas.ch>

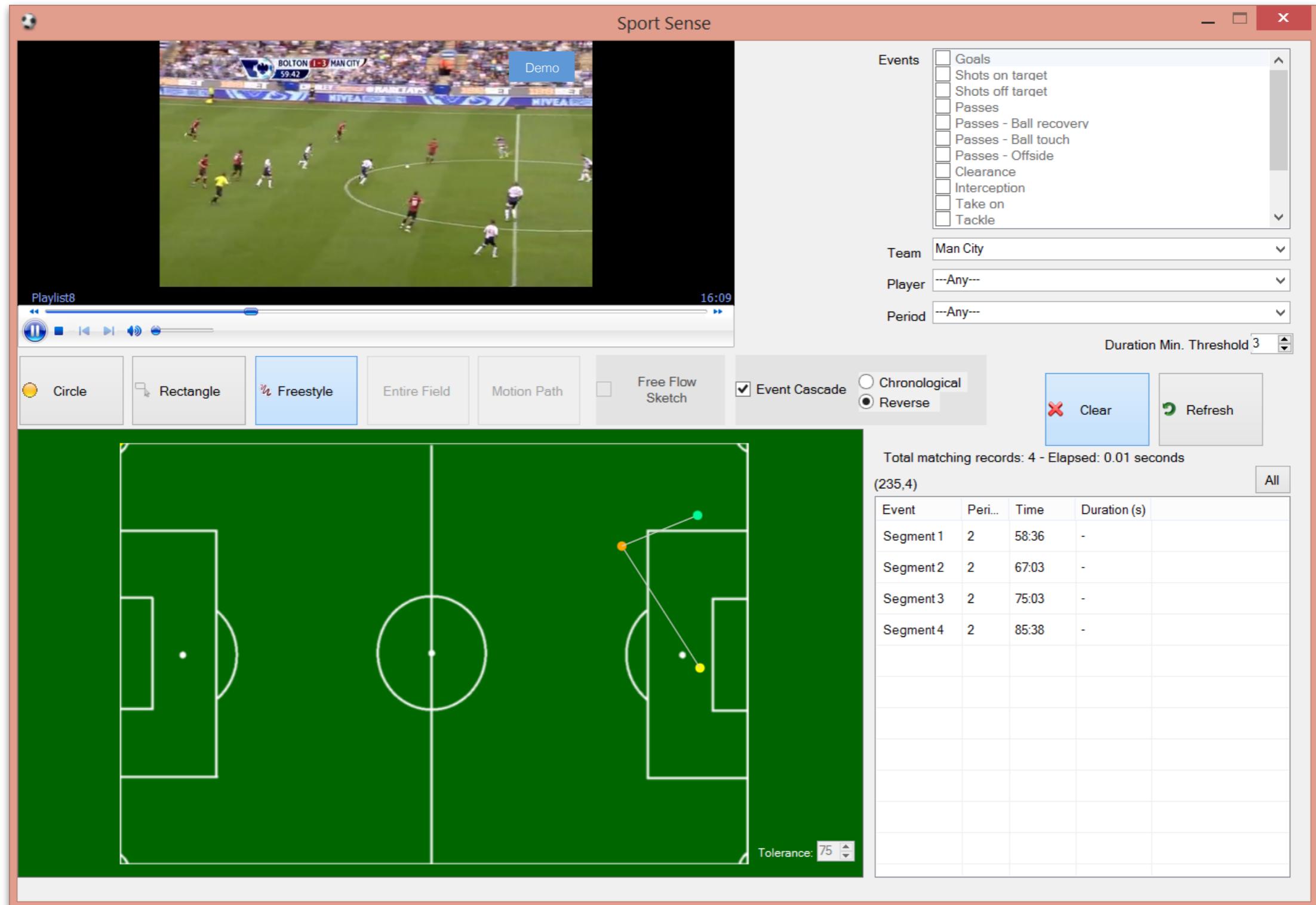
Databases and Information Systems Research Group
Department of Mathematics and Computer Science, University of Basel, Switzerland

November 7, 2014



SportSense - Making Sense of Sports

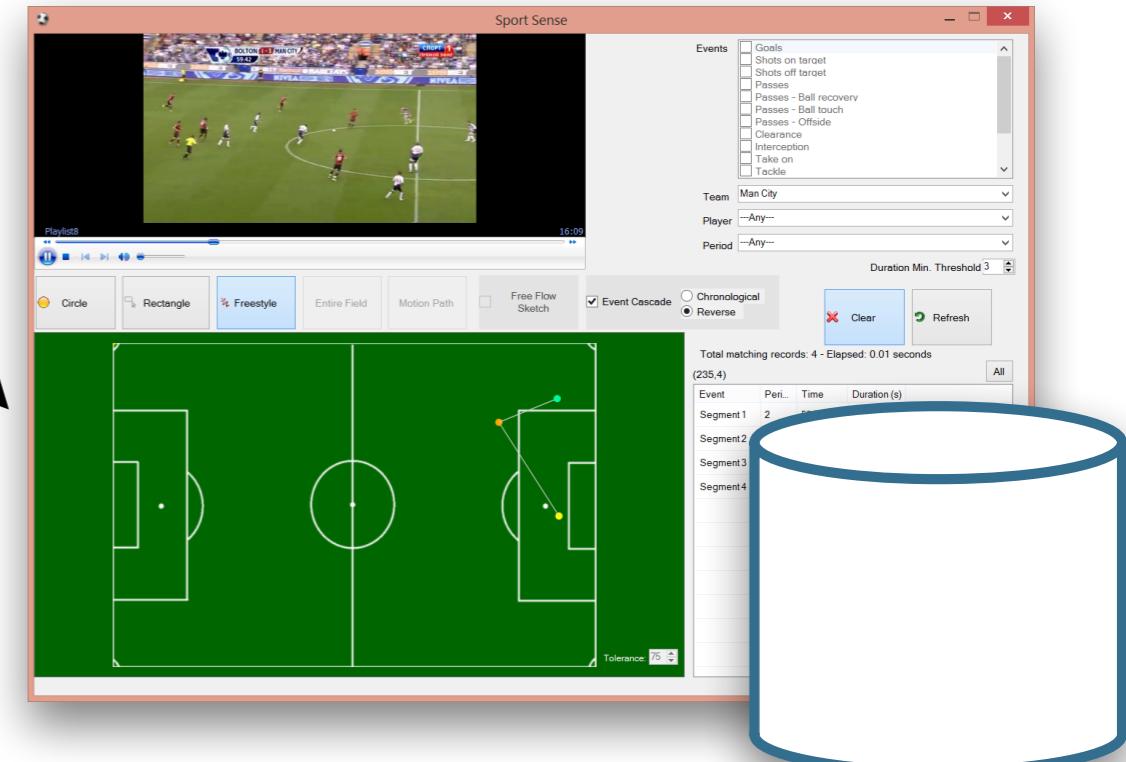
I. Al Kabary and Heiko Schuldt. SportSense: Using Motion Queries to Find Scenes in Sports Videos. In Proc. Int. Conf. on Information and Knowledge Management (CIKM 2013), pages 2489-2492, San Francisco, USA, 2013.



Rationale

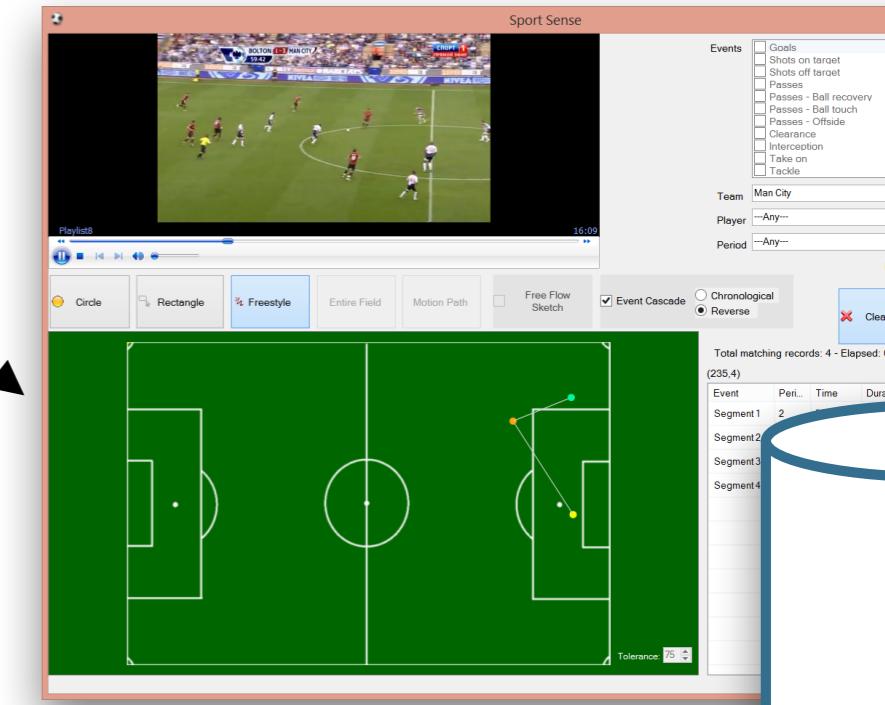
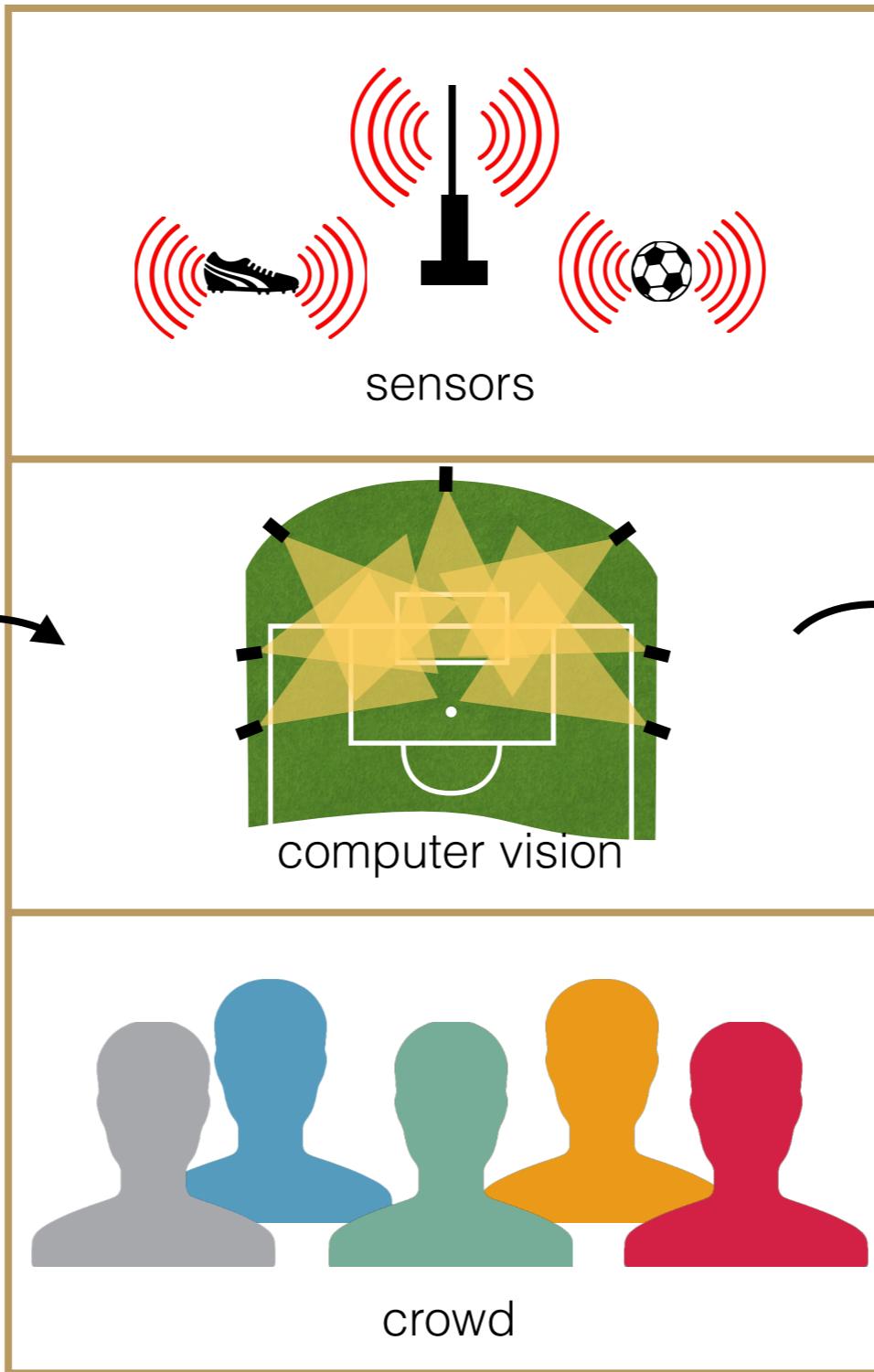


video data



structured data

Rationale



video data

structured data

Architecture

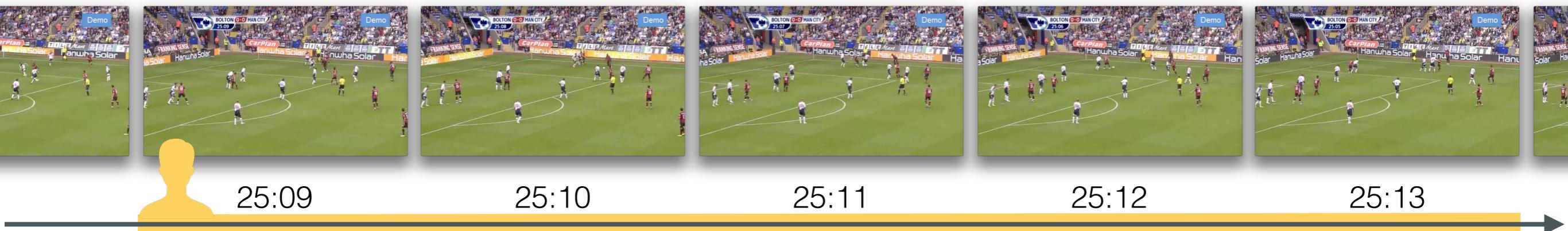
Microworkers.com



CrowdSport



CrowdSport



Task

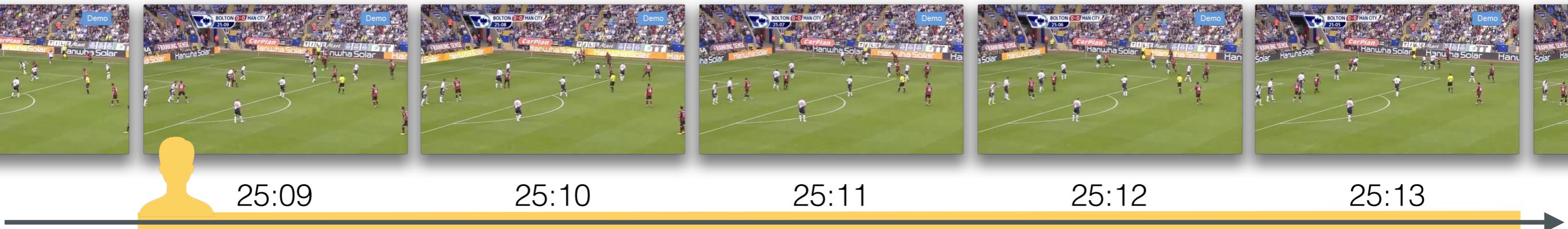
Please annotate the following 5 second snippet with all events.



25:09

Pass
Bolton Wanderers F.C.
(80,90)
25:09

CrowdSport



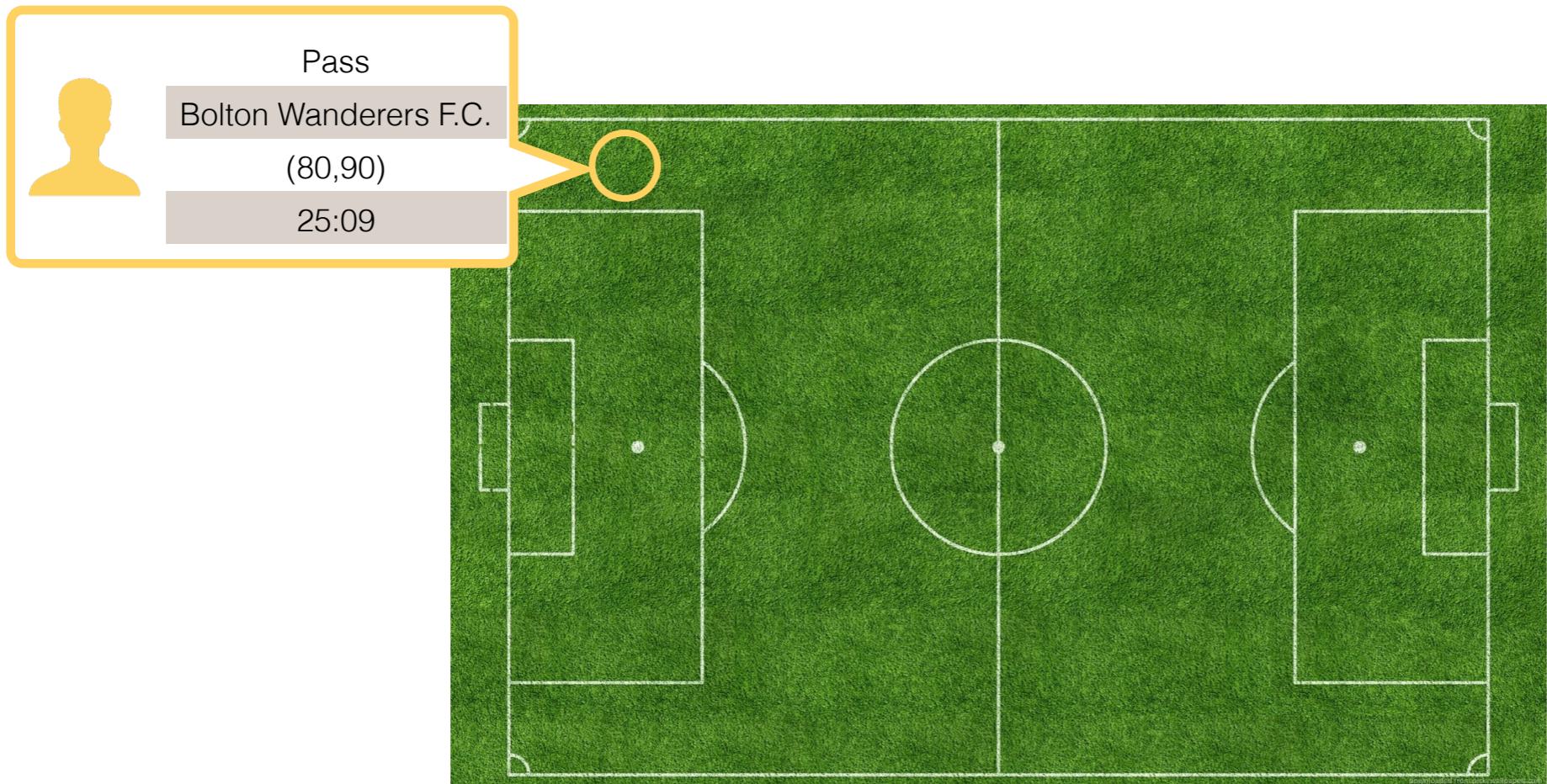
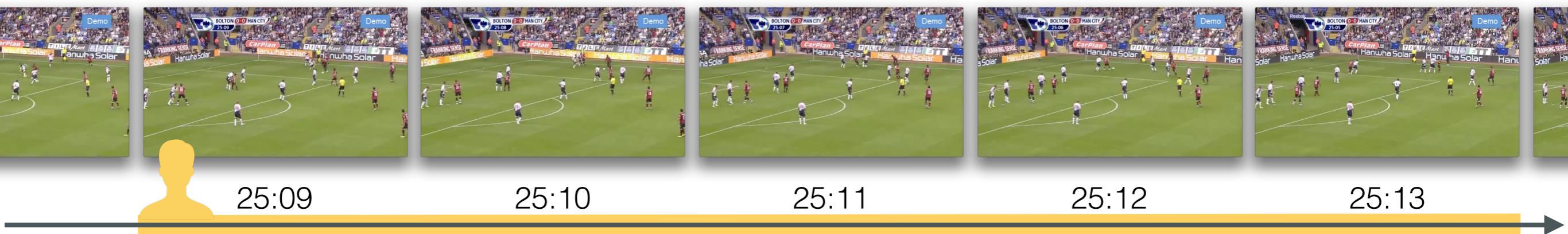
Task

Please annotate the following 5 second snippet with all events.

$$ER = \{\text{type}, \text{team}, \text{position}, \text{time}\}$$

Event Type	Team	Position	Time
goal	Bolton Wanderers F.C.	$x \in [0, 1200]$	$t \in [0, 5400]$
pass	Manchester City F.C.	$y \in [0, 900]$	
tackle			
shot on target			
shot off target			
interception			
foul			
out			
corner kick			
penalty card			

CrowdSport

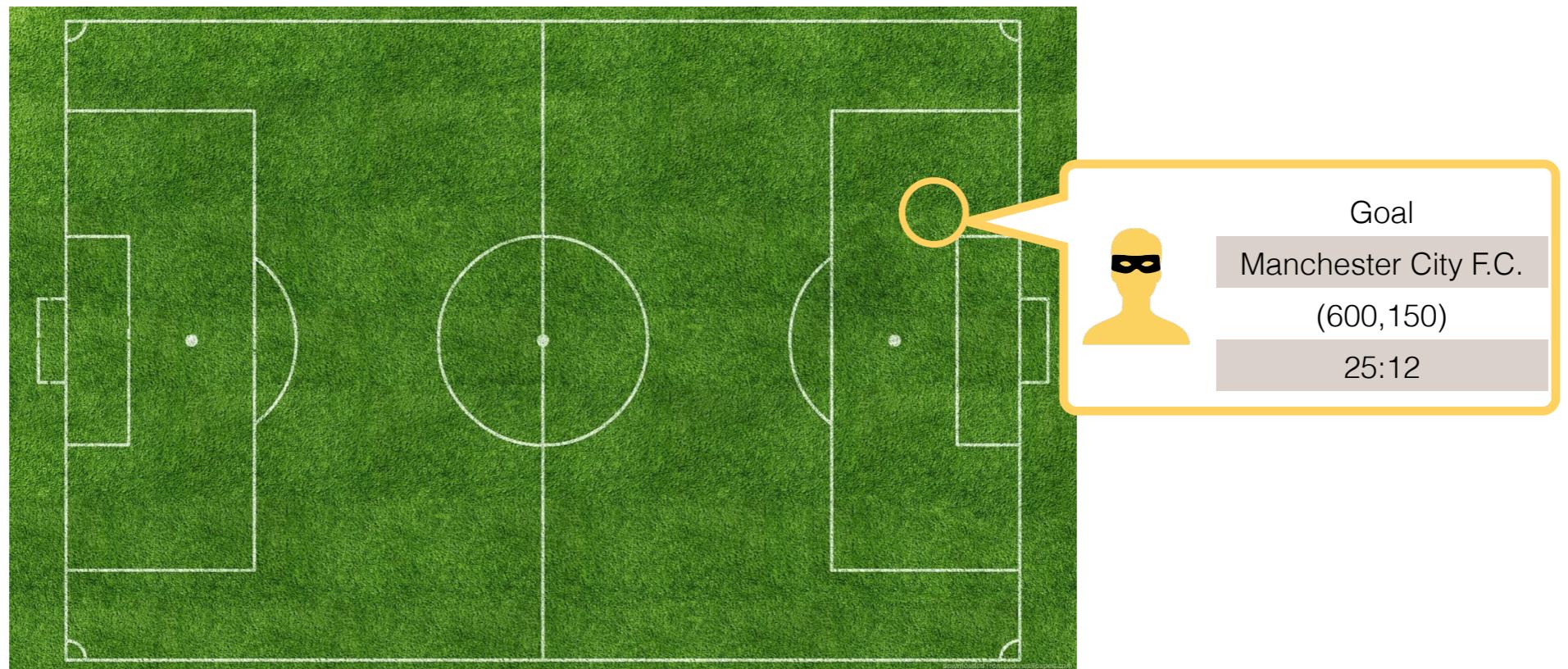


CrowdSport

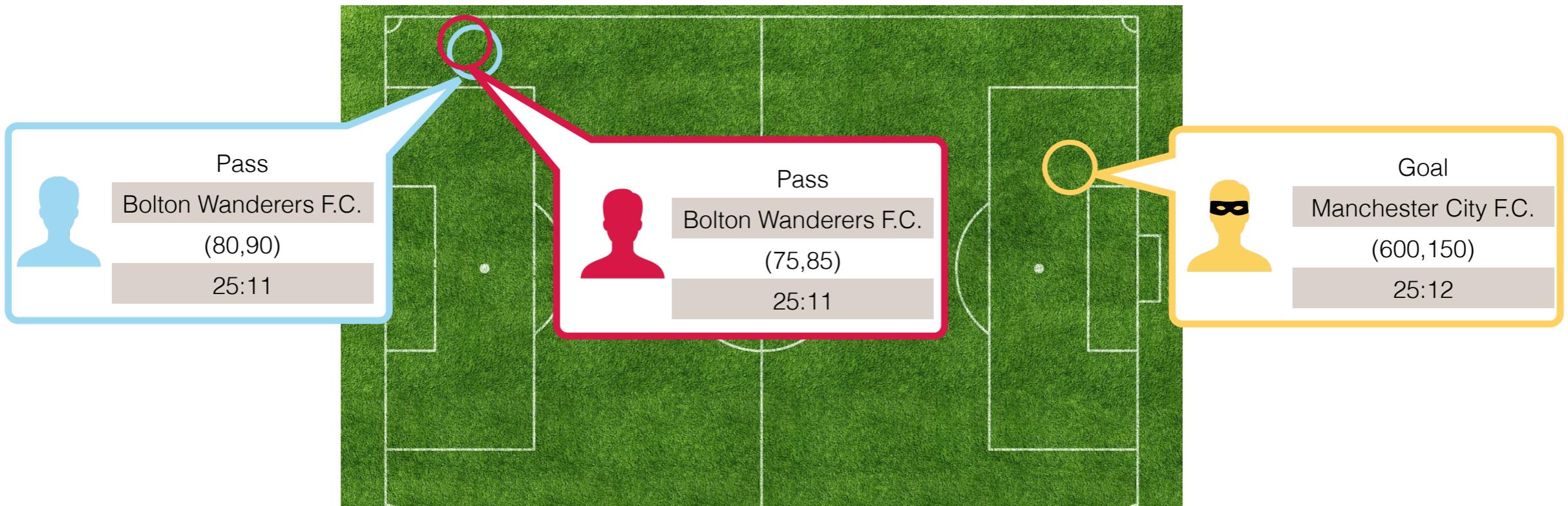
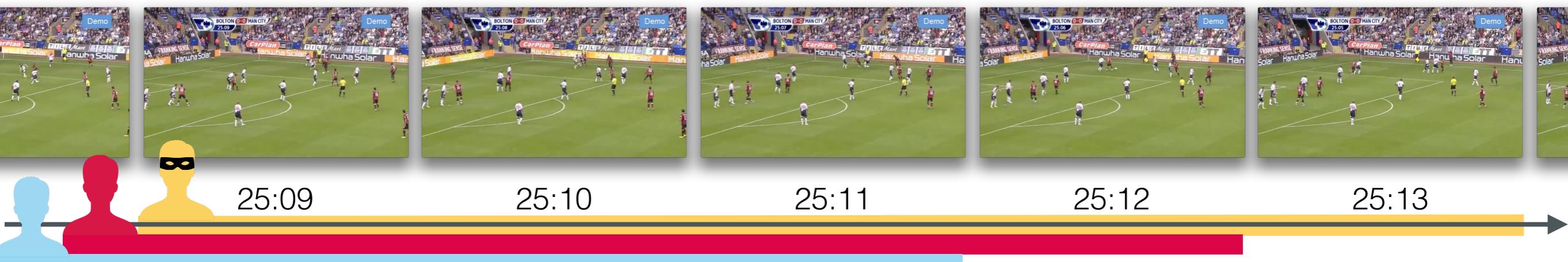


Problem

Bad users may (intentionally/unintentionally) corrupt the data.



Data Quality

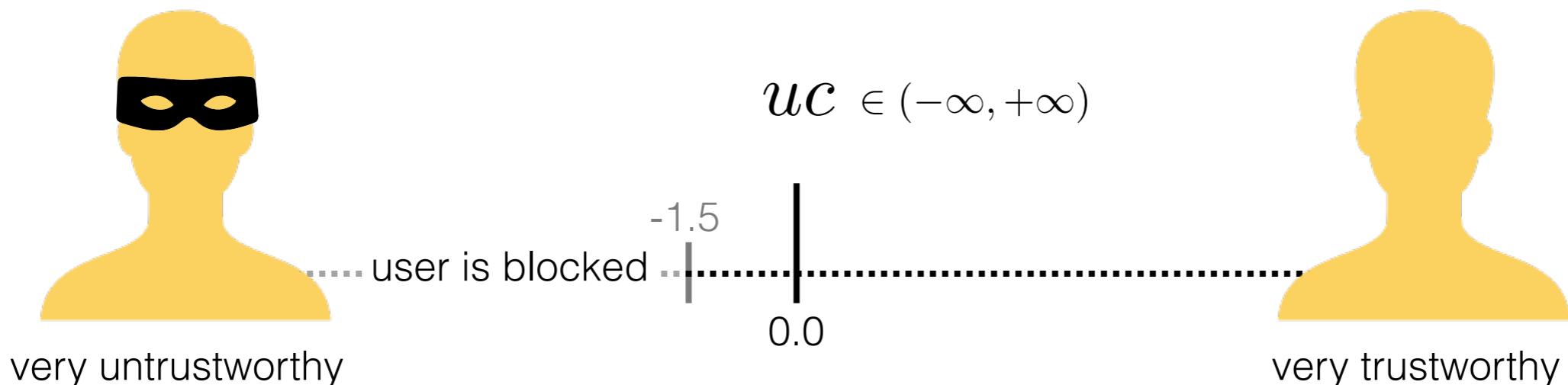
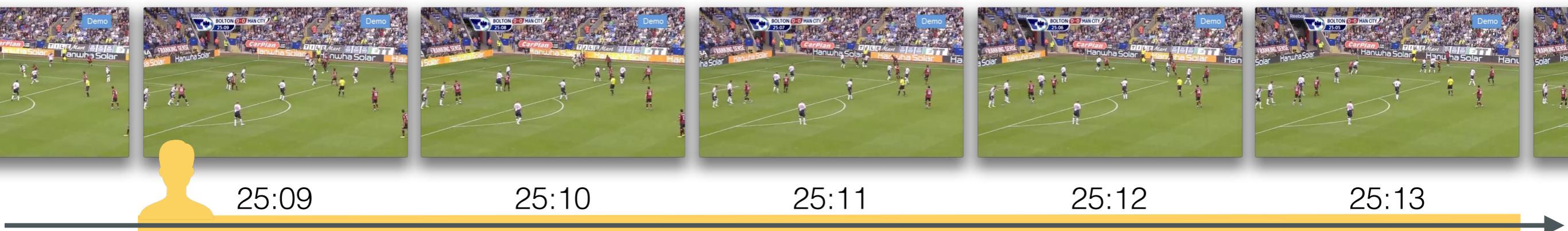


Measure 1

Collect the data from multiple users.

Data Quality

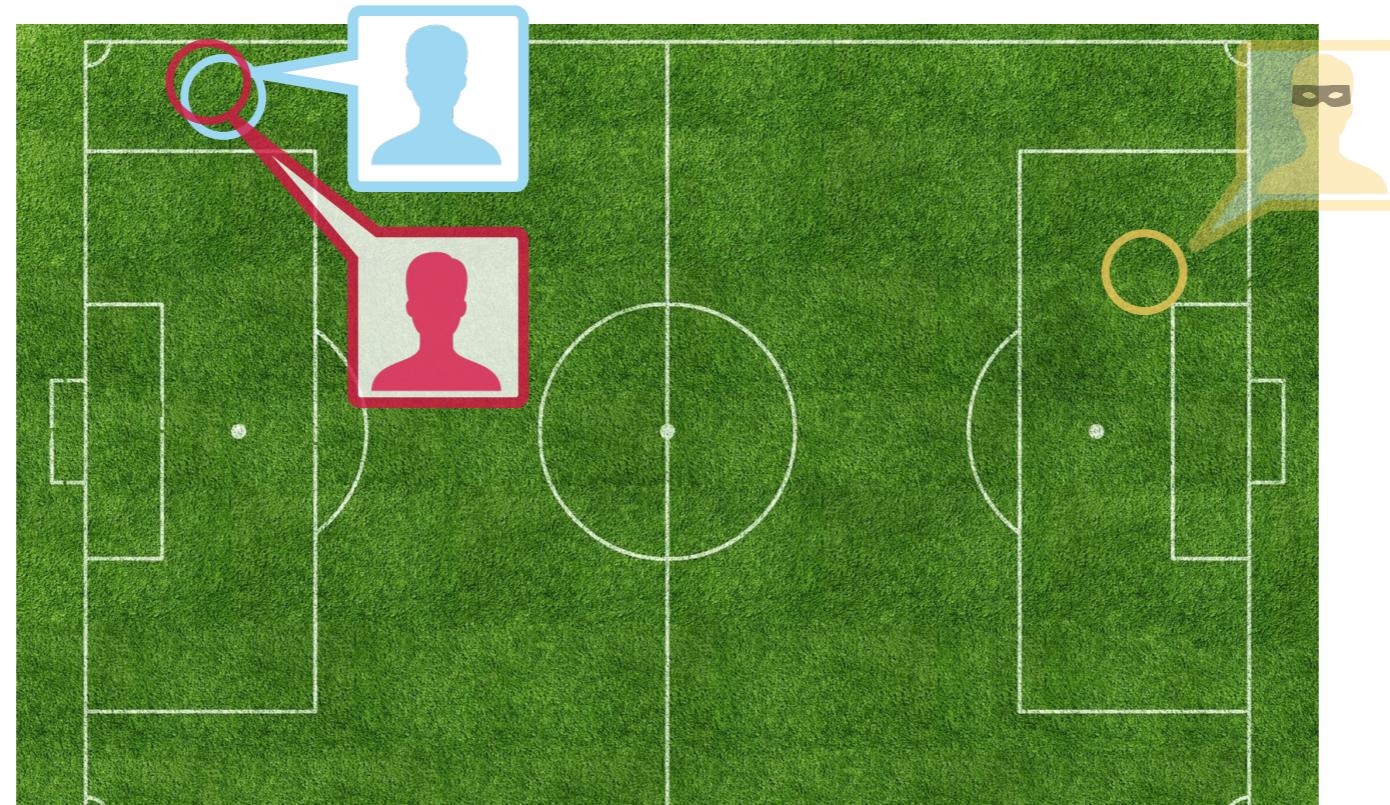
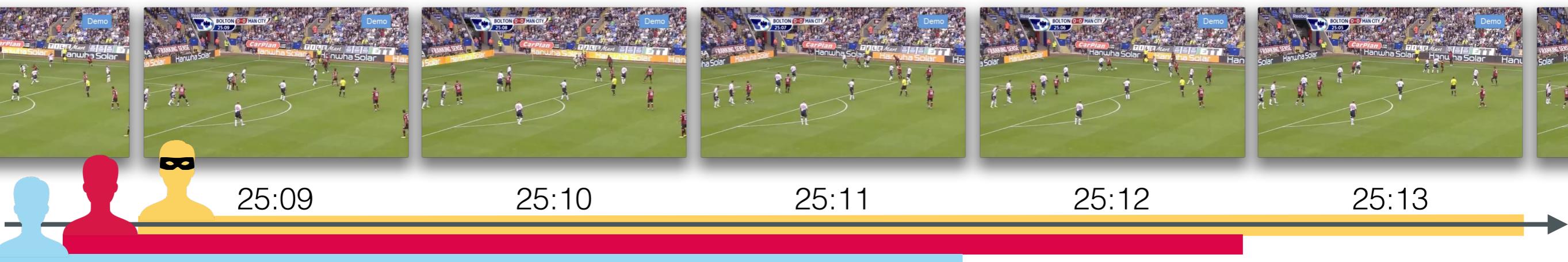
A. Doan and R. McCann. Building Data Integration Systems: A Mass Collaboration Approach. In Proc. IJCAI W. on Information Integration on the Web (IIWeb 2003), pages 183-188, Acapulco, Mexico, 2003.



Measure 2

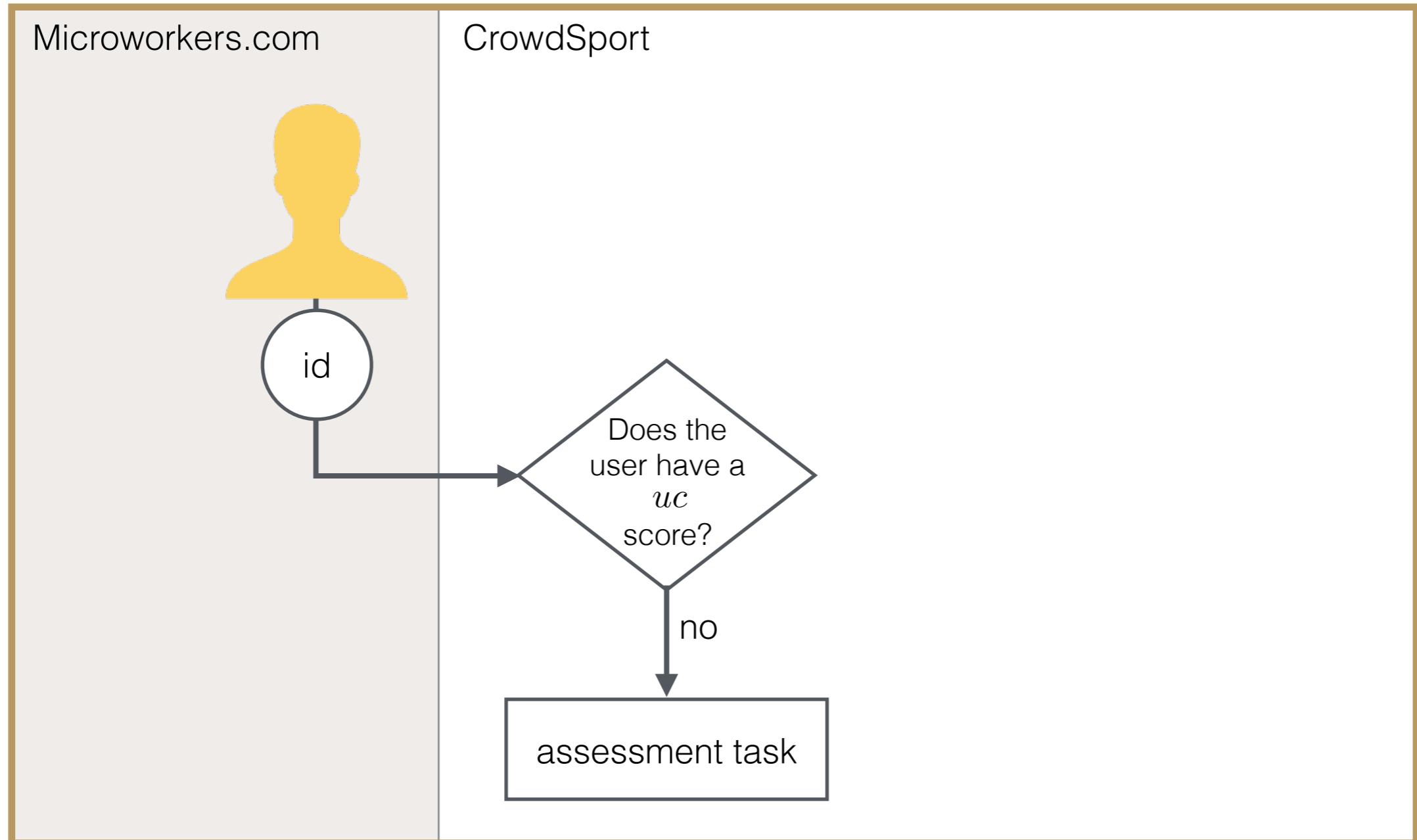
Assess and attach to each user a confidence score.

Data Quality

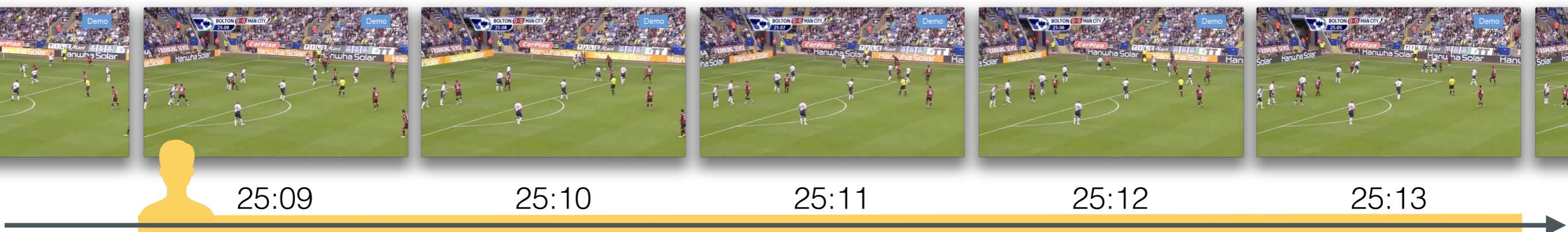


Solution Collect the data from many users and weight their entries by their confidence scores.

Architecture



Assessment Task



Task

Please annotate the following 5 second snippet with all events.

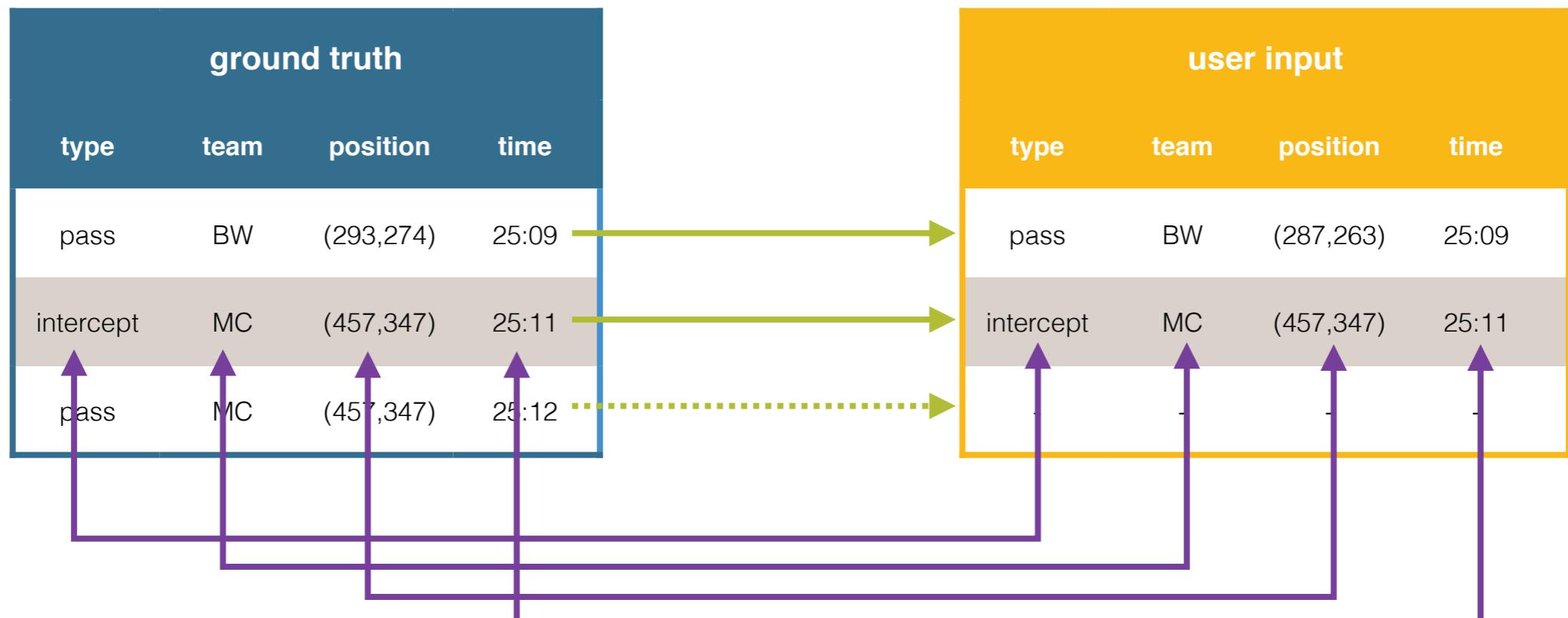
ground truth				user input			
type	team	position	time	type	team	position	time
pass	BW	(293,274)	25:09	pass	BW	(287,263)	25:09
intercept	MC	(457,347)	25:11	intercept	MC	(457,347)	25:11
pass	MC	(457,347)	25:12	-	-	-	-

User Confidence Score

ground truth				user input			
type	team	position	time	type	team	position	time
pass	BW	(293,274)	25:09	pass	BW	(287,263)	25:09
intercept	MC	(457,347)	25:11	intercept	MC	(457,347)	25:11
pass	MC	(457,347)	25:12	-	-	-	-

$$uc = \sum_{e \in E_{\text{init}}} \text{argmax } r_e$$

User Confidence Score



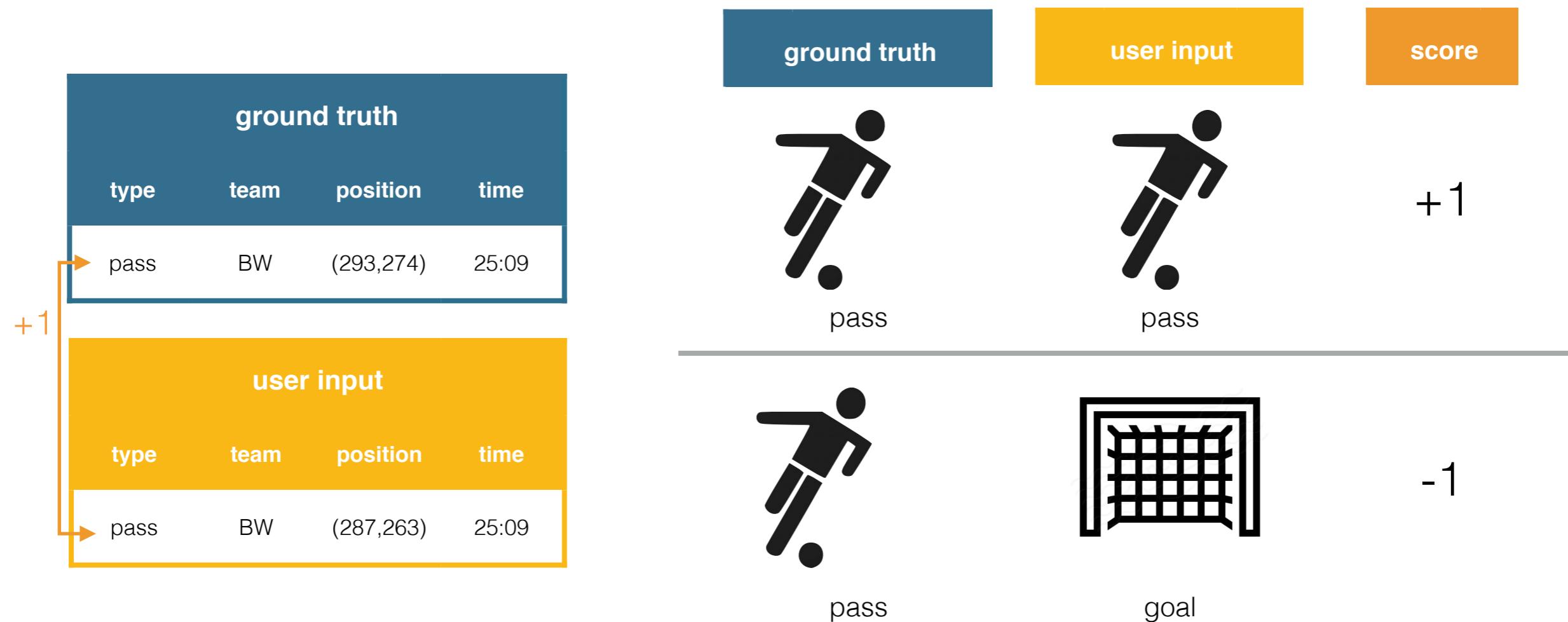
$$r_e = \sum_{i \in ER} w_i r_i(e)$$

User Confidence Score

ground truth			
type	team	position	time
pass	BW	(293,274)	25:09

user input			
type	team	position	time
pass	BW	(287,263)	25:09

User Confidence Score

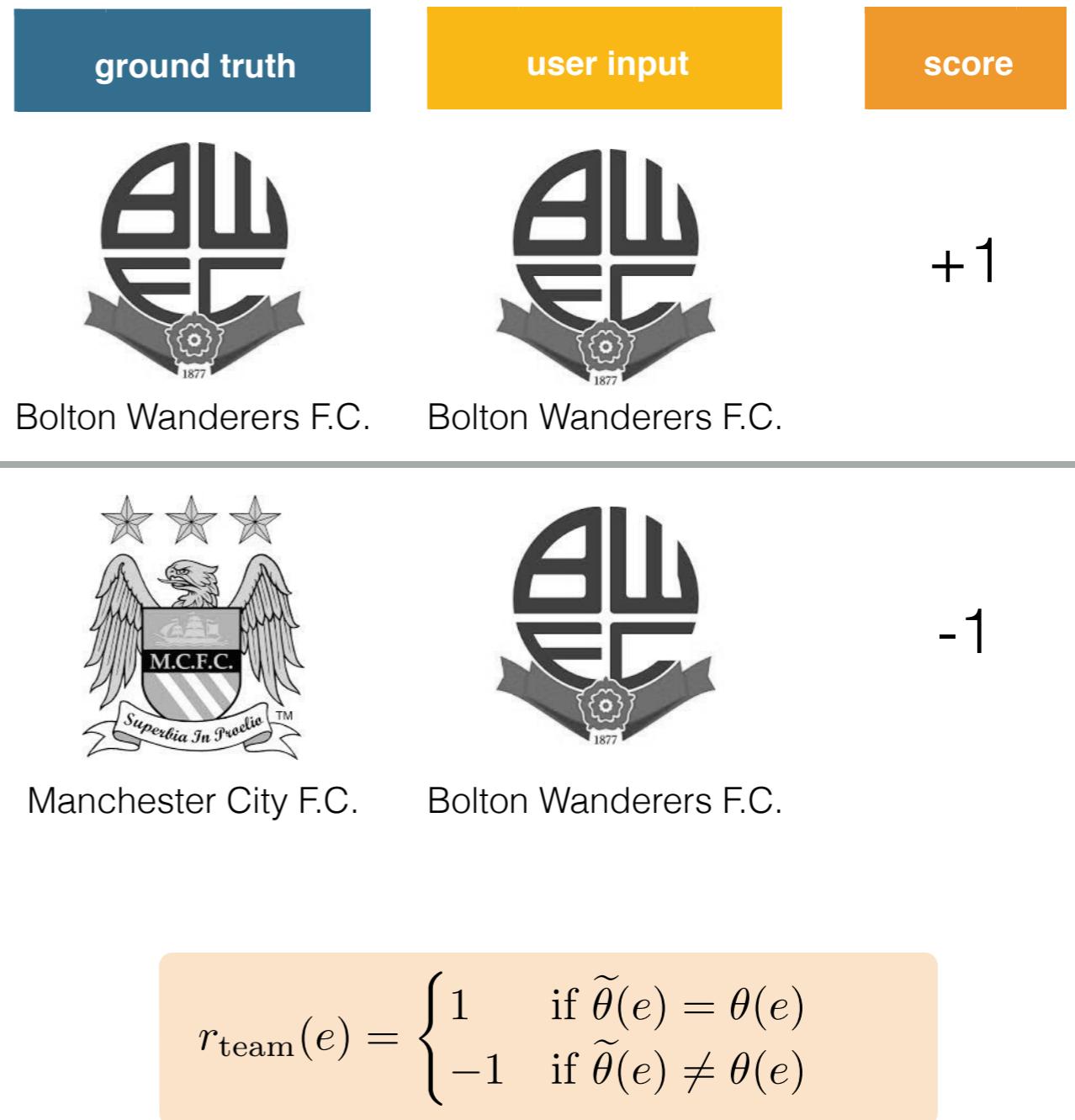


$$r_{\text{type}}(e) = \begin{cases} 1 & \text{if } \tilde{\vartheta}(e) = \vartheta(e) \\ -1 & \text{if } \tilde{\vartheta}(e) \neq \vartheta(e) \end{cases}$$

User Confidence Score

ground truth			
type	team	position	time
pass	BW	(293,274)	25:09

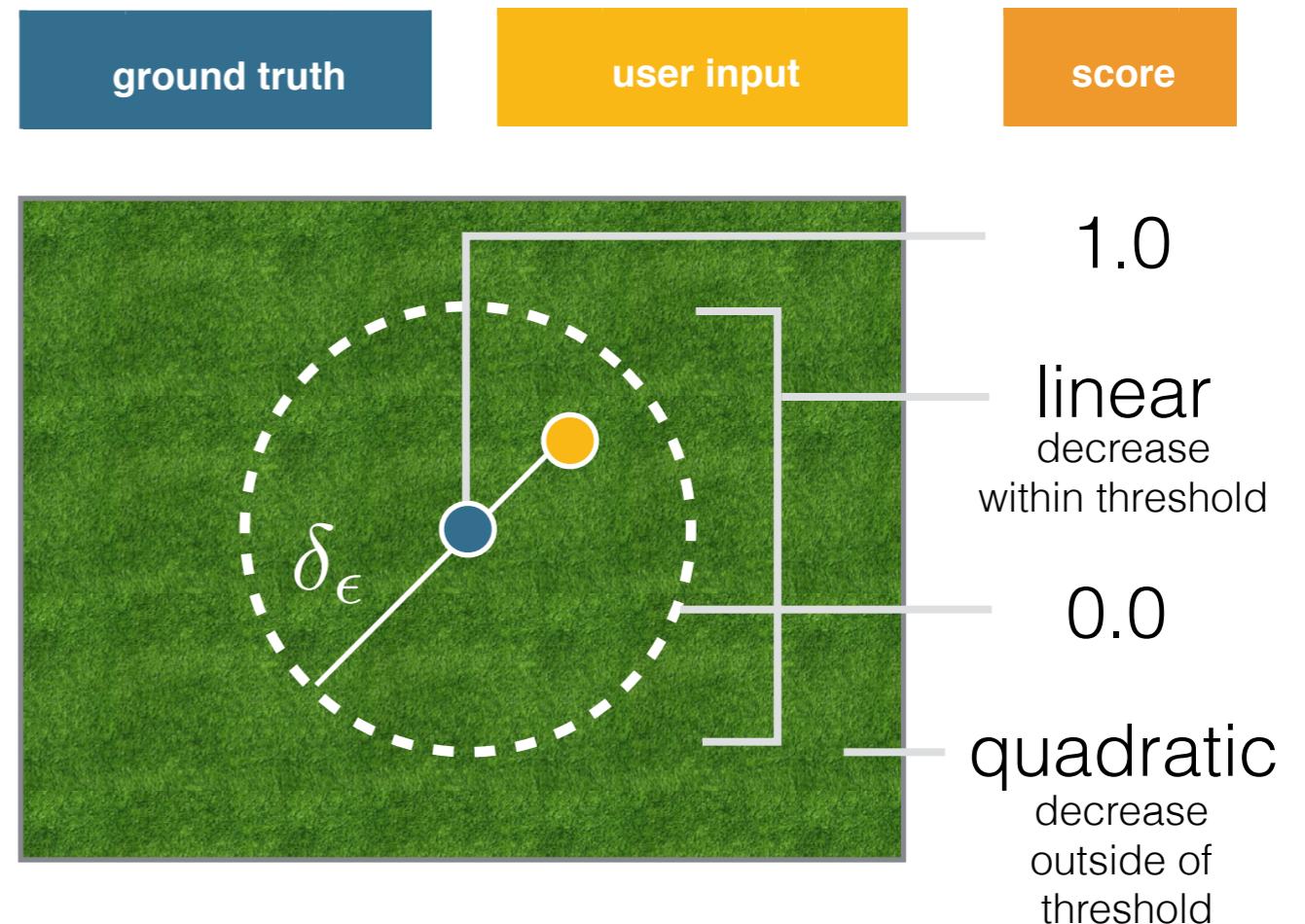
type	team	position	time
pass	BW	(287,263)	25:09



User Confidence Score

ground truth			
type	team	position	time
pass	BW	(293,274)	25:09

+0.4	→		
pass	BW	→ (287,263)	25:09



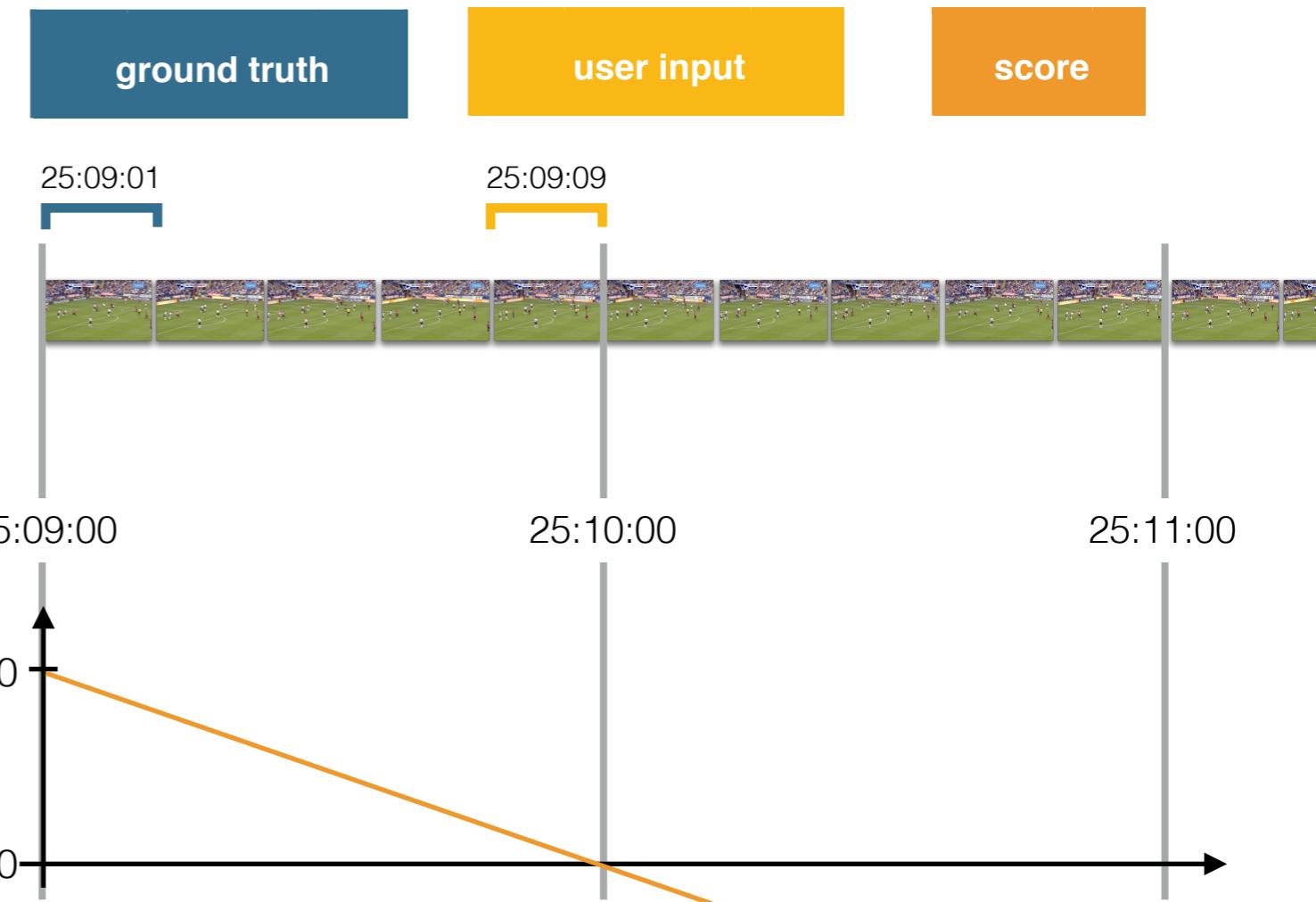
$$r_{\text{pos}}(e) = 1 - \begin{cases} \frac{\delta(e)}{\delta_\epsilon} & \text{if } \delta(e) > \delta_\epsilon \\ \left(\frac{\delta(e)}{\delta_\epsilon}\right)^2 & \text{if } \delta(e) \leq \delta_\epsilon \end{cases}$$

User Confidence Score

ground truth			
type	team	position	time
pass	BW	(293,274)	25:09

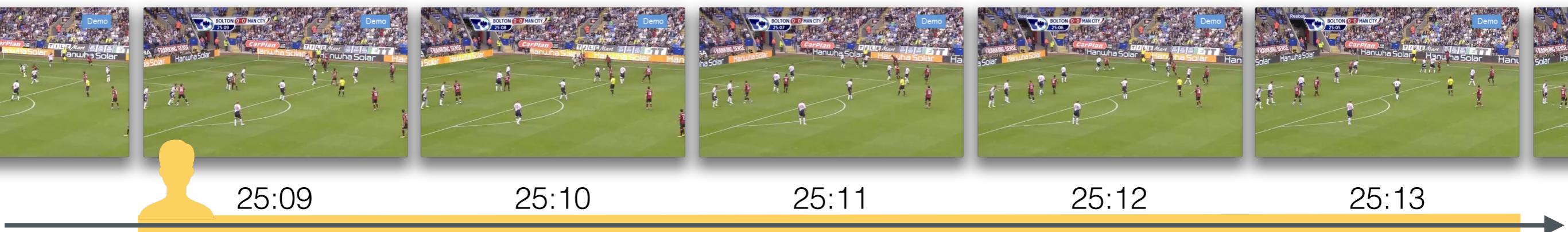
-0.4

user input			
type	team	position	time
pass	BW	(287,263)	25:09



$$r_{\text{time}}(e) = 1 - 2 |\tilde{\tau}(e) - \tau(e)|$$

Assessment Task



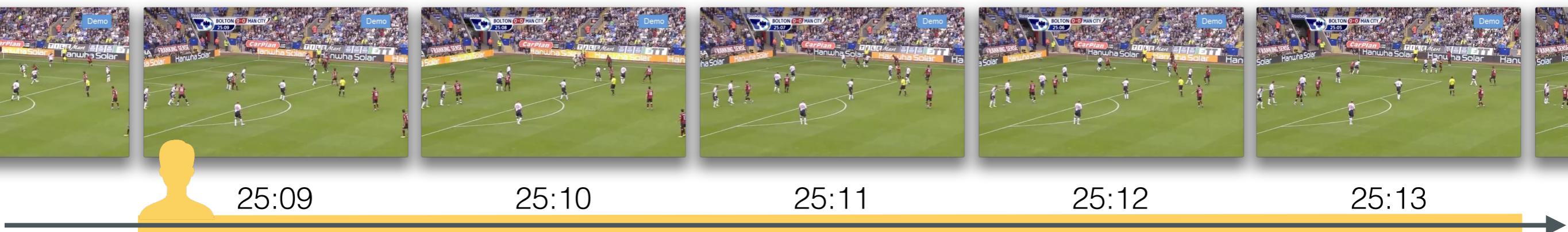
Task

Please annotate the following 5 second snippet with all events.

ground truth				user input				score
type	team	position	time	type	team	position	time	
pass	BW	(293,274)	25:09	pass	BW	(287,263)	25:09	+0.5
intercept	MC	(457,347)	25:11	intercept	MC	(457,347)	25:11	+1
pass	MC	(457,347)	25:12	-	-	-	-	-0.5

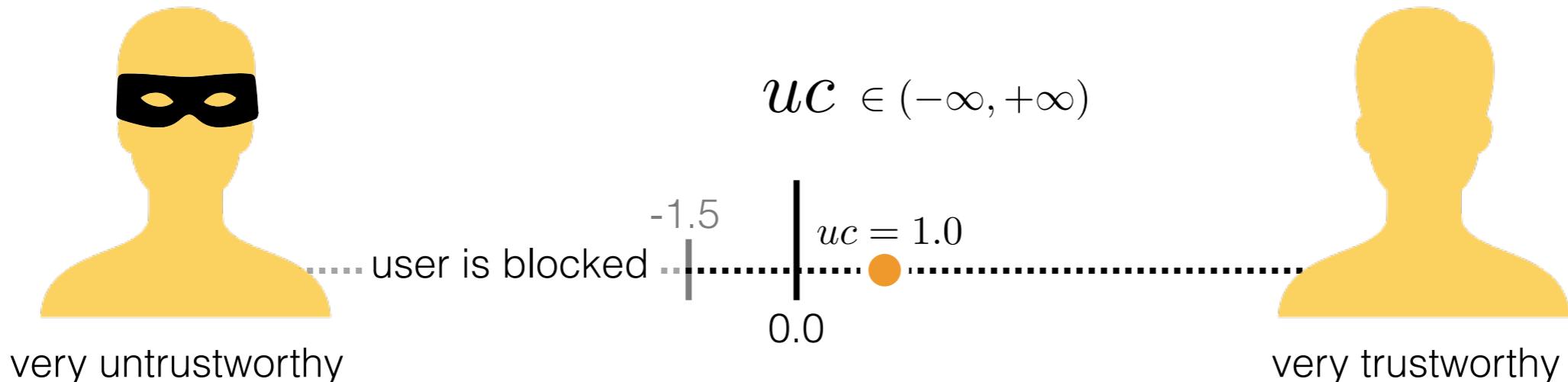
$$uc = \sum_{e \in E_{init}} \operatorname{argmax} r_e$$

Assessment Task

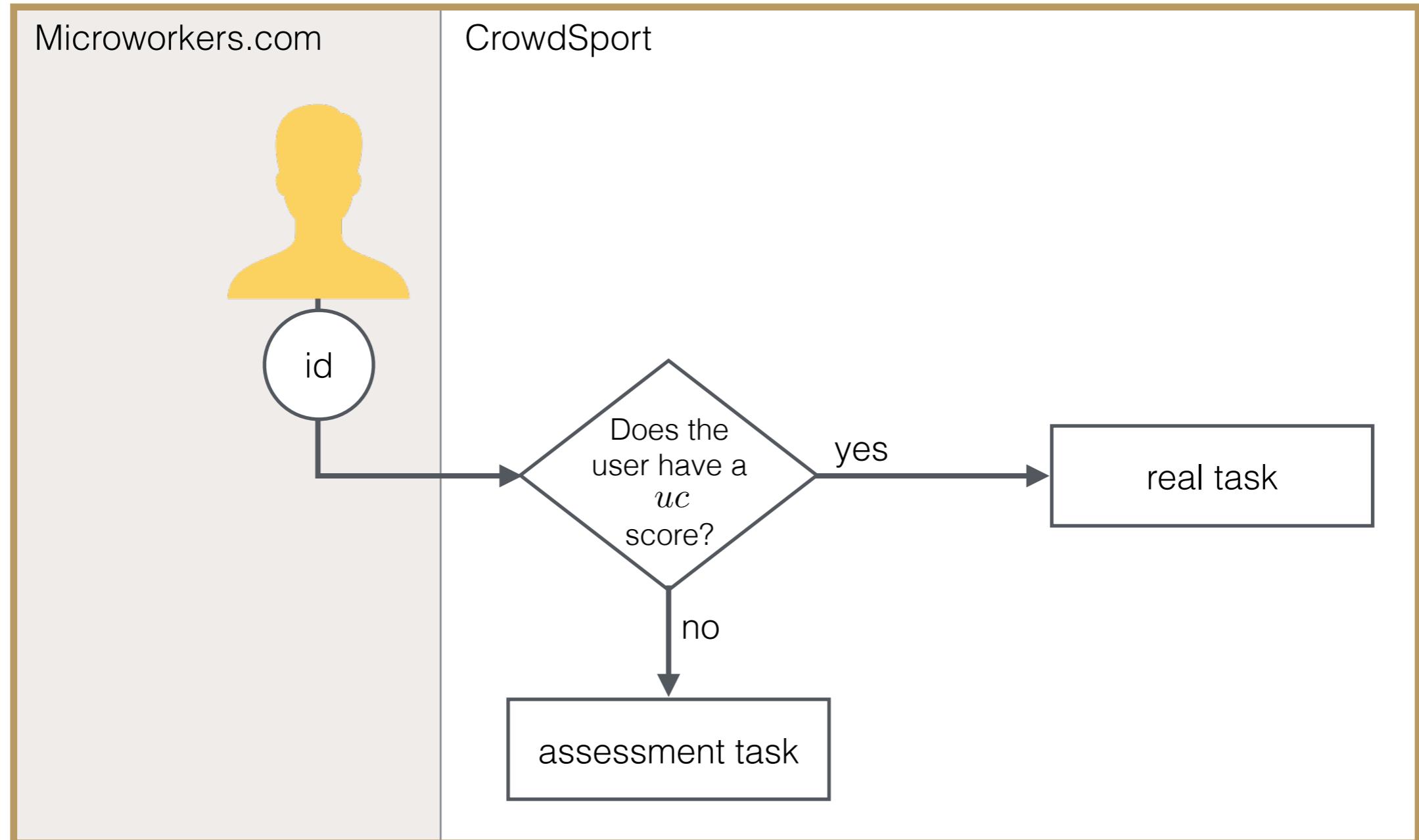


Task

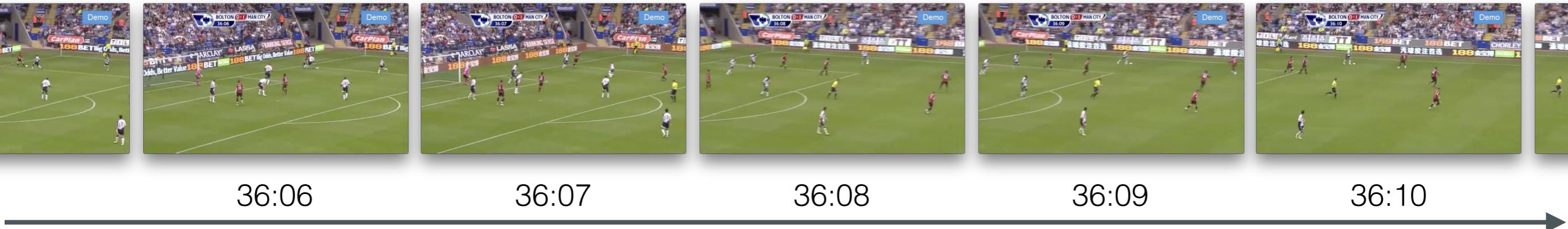
Please annotate the following 5 second snippet with all events.



Architecture



Task

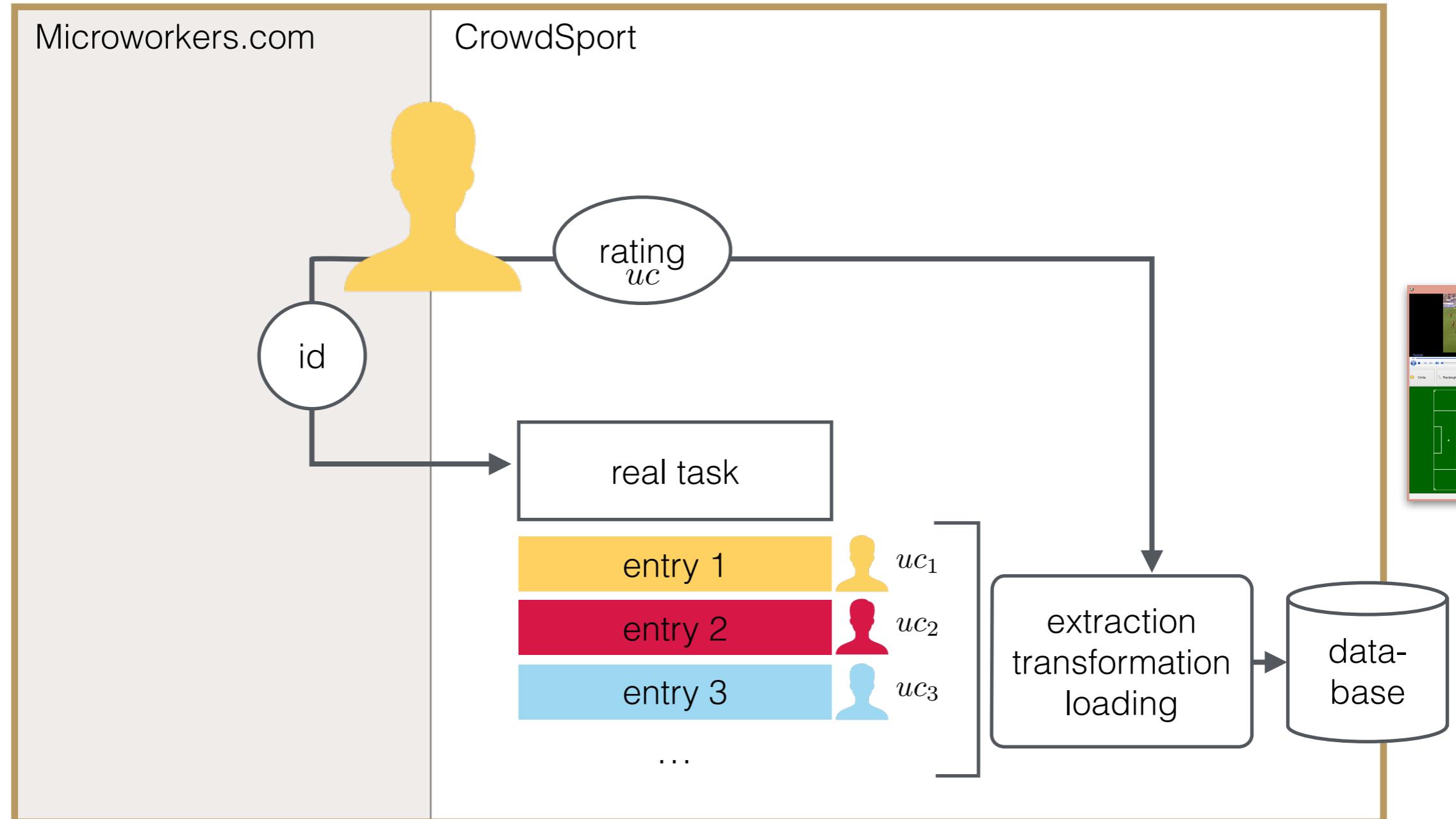


Task

Please annotate the following 5 second snippet with all events.

user input			
type	team	position	time
pass	BW	(8,82)	36:06
intercept	BW	(87,115)	36:06
pass	BW	(116,61)	36:09

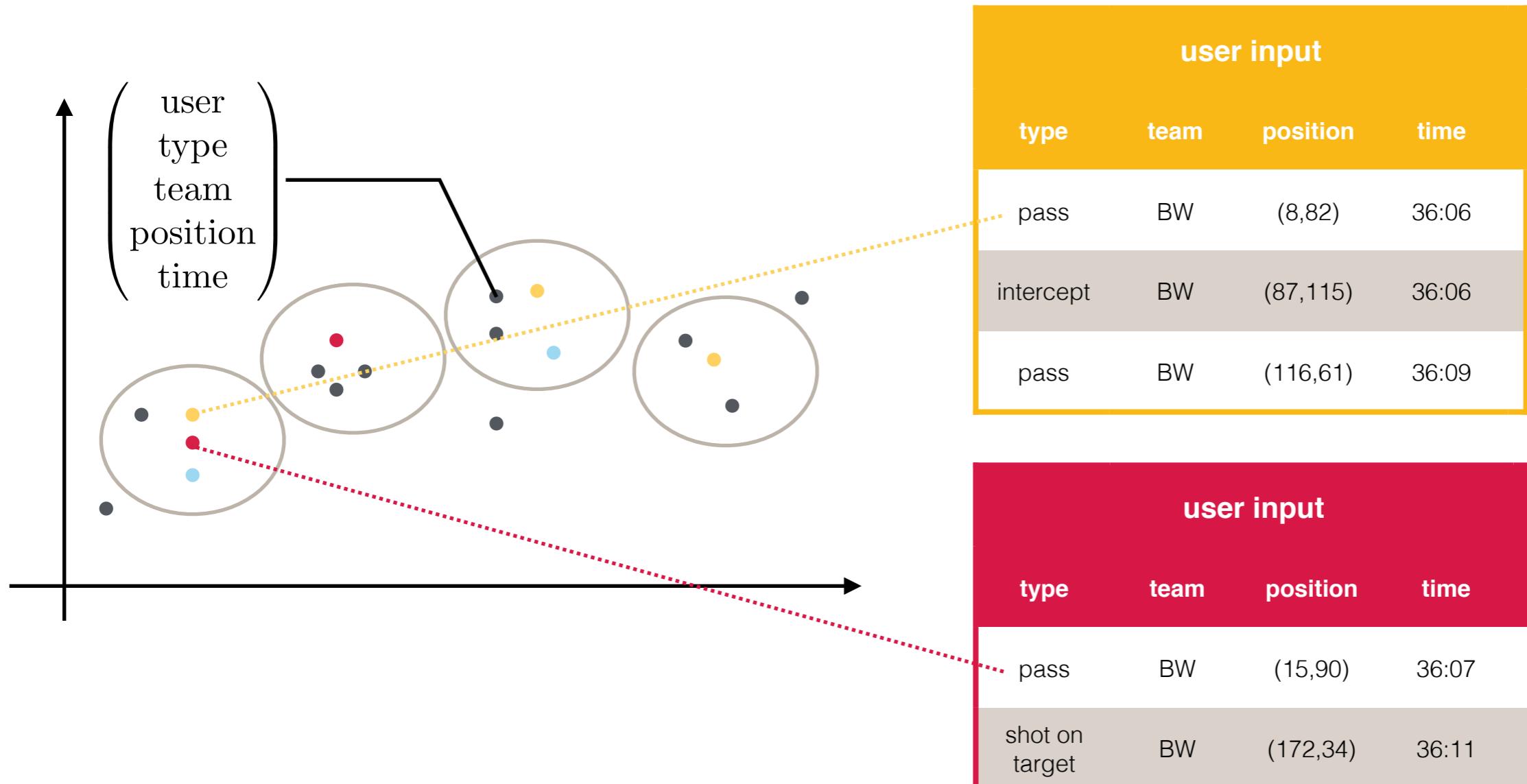
Architecture



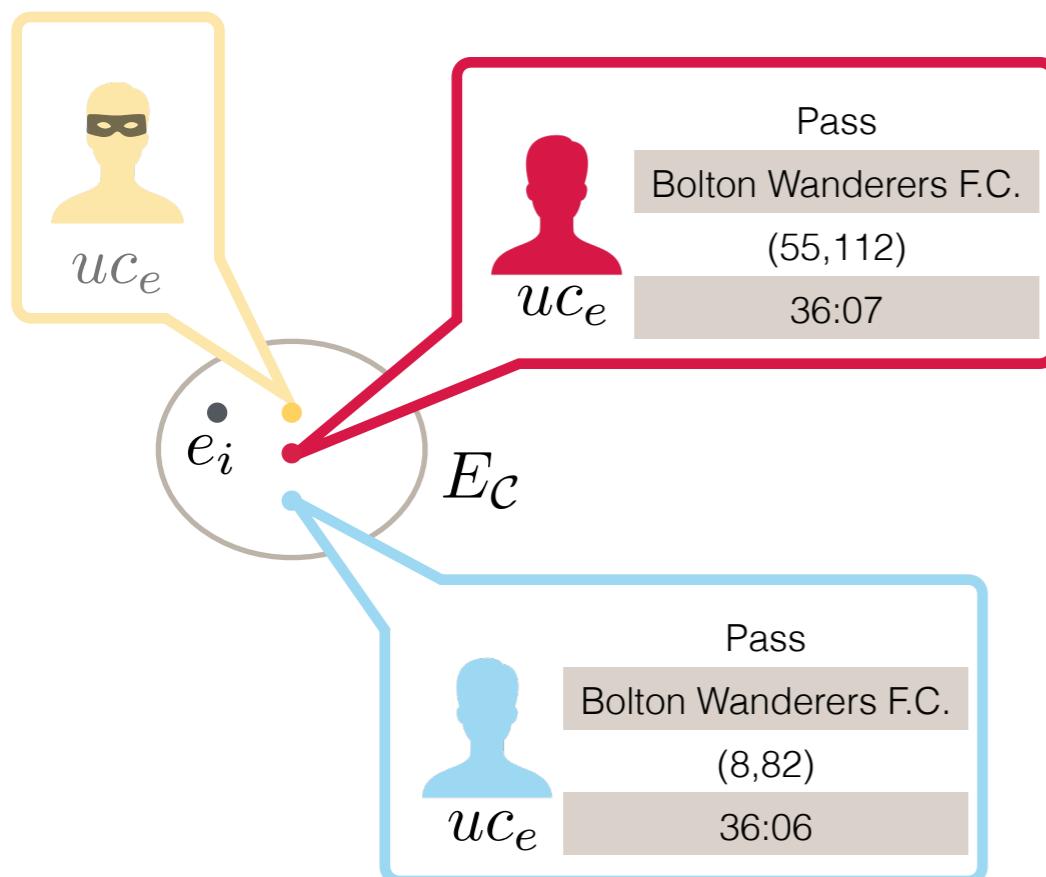
Extraction, Transformation, Loading

M. Ester, H.-P. Kriegel, J. Sander, and X. Xu. A Density-Based Algorithm for Discovering Clusters in Large Spatial Databases with Noise.
In Proc. Int. Conf. on Knowledge Discovery and Data Mining (KDD 1996), pages 226–231, Portland, USA, 1996. AAAI.

DBScan Algorithm



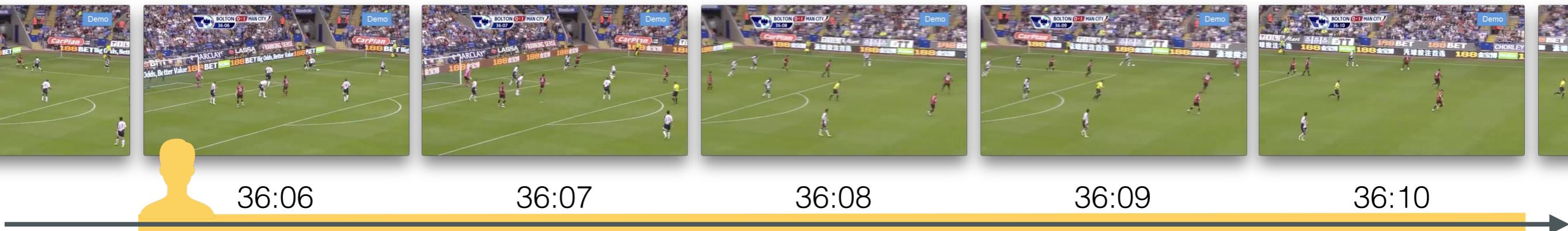
Extraction, Transformation, Loading



$$pos' = \frac{\sum_{e \in E_c} pos(e) uc_e}{\sum_{e \in E_c} uc_e}$$
$$time' = \frac{\sum_{e \in E_c} time(e) uc_e}{\sum_{e \in E_c} uc_e}$$

type'
team'
majority
weight by score

Update Confidence Score



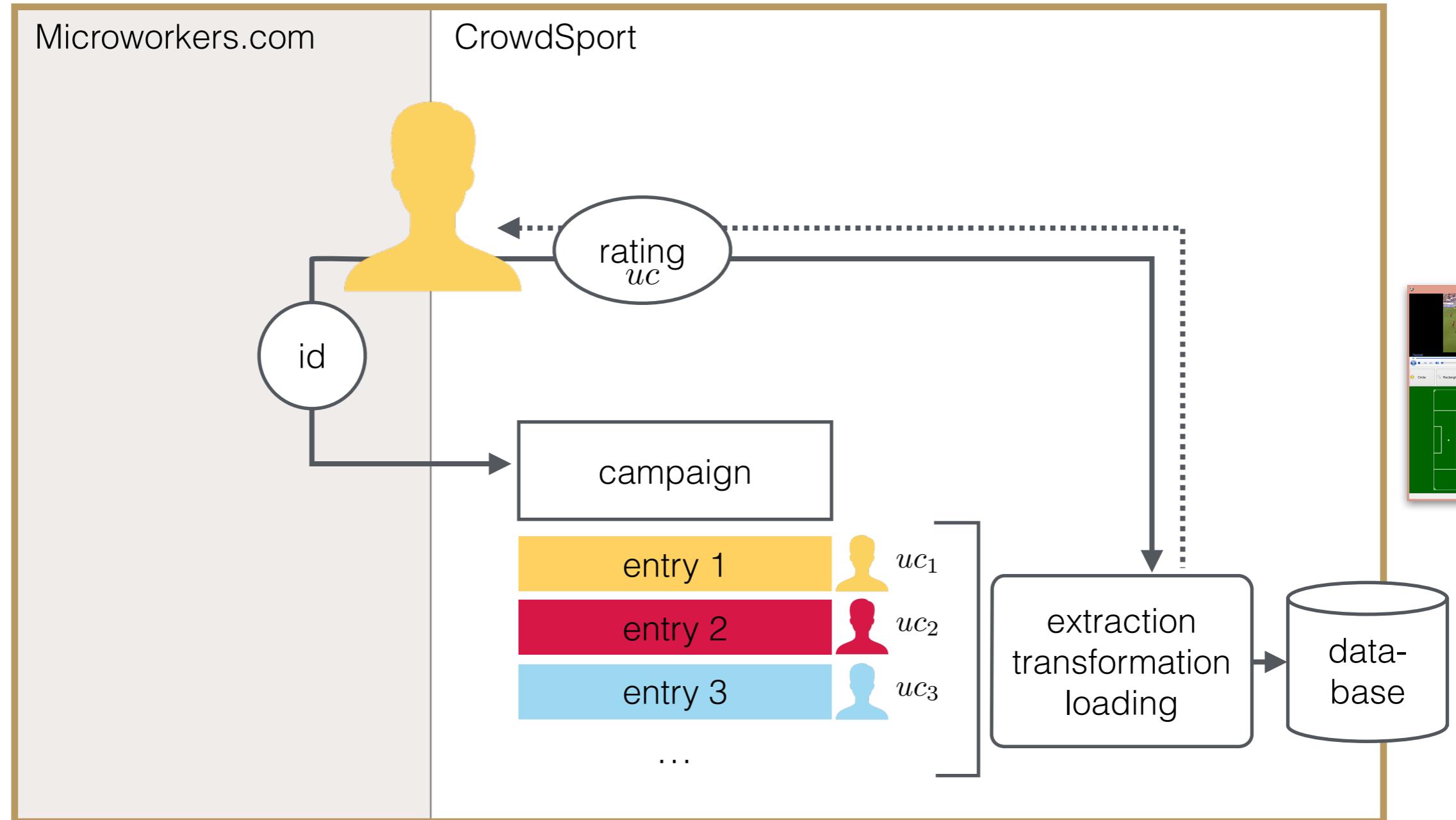
Task

Please annotate the following 5 second snippet with all events.

computed ground truth				user input				score
type	team	position	time	type	team	position	time	
pass	BW	(8,82)	36:06	pass	BW	(8,82)	36:06	
intercept	MC	(87,115)	36:06	intercept	BW	(87,115)	36:06	
pass	MC	(116,61)	36:09	pass	BW	(116,61)	36:09	

Score is updated as done with the assessment task.

Architecture



Architecture

Microworkers.com

search, click and engage

0.20 US\$

est. 5 minutes

Bolton Wanderers - Manchester City

1. Go to the image frame on which you identify an event to add.

4. Set the point on the field to denote where the event happened or cancel adding this event.

Click to play video.

Current Time : 2:13.30

You are inside the sequence to tag.

Added events

ID	Team	Event	Time	Position	Delete
0	Bolton Wanderers	Foul	2:12.90	314.66 298.84	

Submit all Events

The screenshot shows a user interface for annotation a football match. At the top, it says "Bolton Wanderers - Manchester City". On the left, there's a video player with a red play button and the text "Click to play video." Below the video player is a green bar with the text "You are inside the sequence to tag.". To the right of the video player is a football pitch with a yellow dot indicating the event location. There are also two blue arrows pointing towards the yellow dot. At the bottom, there's a table titled "Added events" with one row:

ID	Team	Event	Time	Position	Delete
0	Bolton Wanderers	Foul	2:12.90	314.66 298.84	

At the bottom right of the interface is a blue button labeled "Submit all Events".



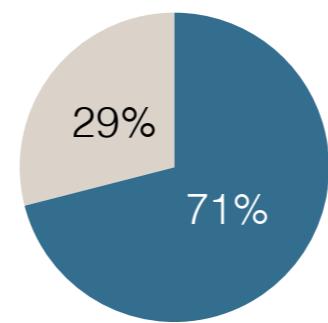
Evaluation: Overview

scenes without replays, slow-motions, etc.

Description	Duration	Workers	Banned
Assessment	5s	709	47%
Test 1	50.5s	101	12%
Test 2	75s	150	8%
Test 3	80s	160	9%

10 user
judgments
per 0.5s

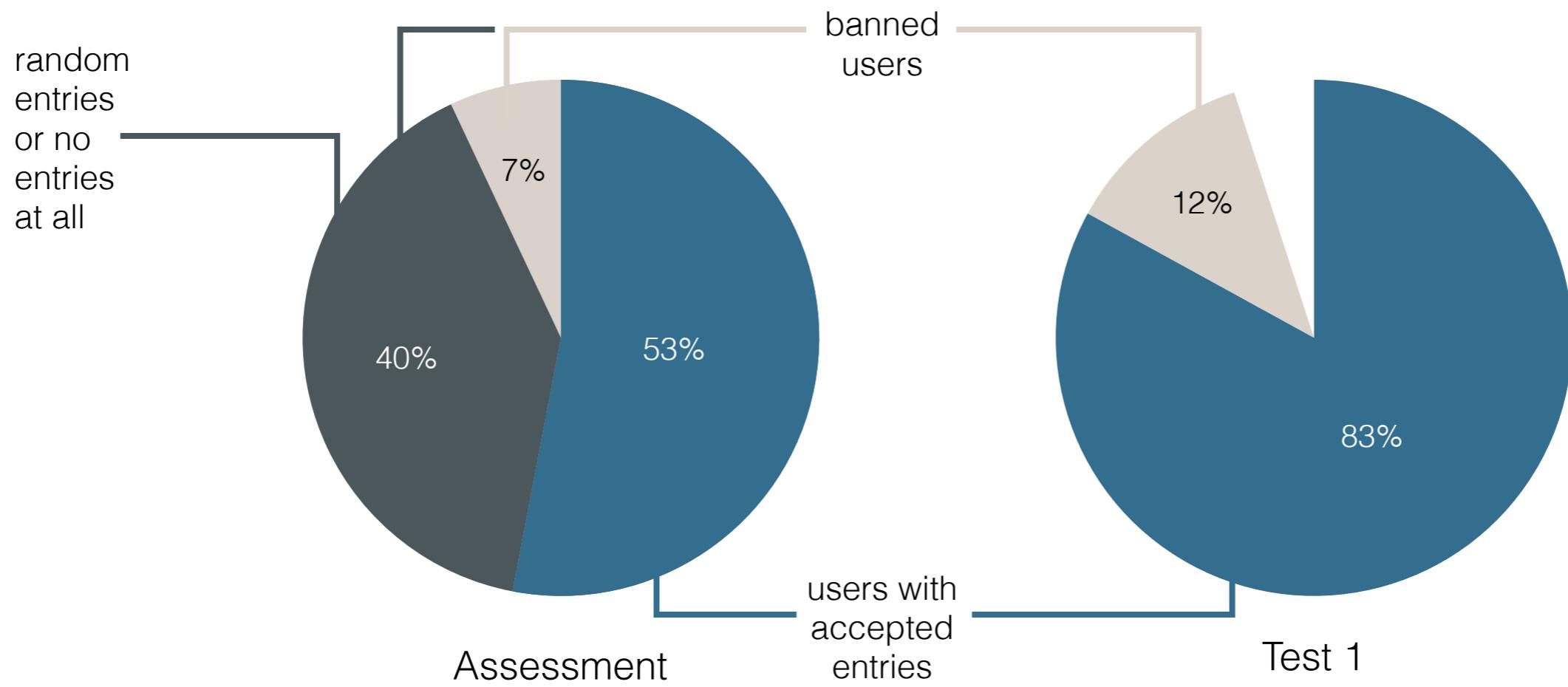
- › evaluation data:
Manchester City vs. Bolton Wanderers
(<http://www.mcfc.co.uk/the-club/mcfc-analytics>)
- › completion in ~30 hours



Evaluation: Overview

Description	Duration	Workers	Banned
Assessment	5s	709	47%
Test 1	50.5s	101	12%
Test 2	75s	150	8%
Test 3	80s	160	9%

banning based
on true ground truth
.....
banning based
on computed
ground truth
(more conservative!)



Evaluation: Overview

Description	Duration	Workers	Banned
Assessment	5s	709	47%
Test 1	50.5s	101	12%
Test 2	75s	150	8%
Test 3	80s	160	9%

Summary I

- › assessment step blocked 40% of the users
(obviously bad users who entered random data or no data at all)
- › rate of banned users is considerably lower in tests
(improvement in quality, *computed ground truth?*)

Evaluation: Test 1

How does the data collected with CrowdSport
compare to the ground truth?

computed by CrowdSport
using crowdsourced data

professionally annotated data set

difference

Evaluation: Test 1

Ground Truth					CrowdSport					Delta			
x	y	time	type	team	x	y	time	type	team	dist	time	type	team
293.6	274.4	33:54	pass	BW	287.8	263.0	33:54	pass	BW	1.96m	0.1s	-	-
457.1	347.5	33:56	intercept	MC	471.4	316.5	33:56	intercept	MC	5.25m	0.1s	-	-
457.1	347.5	33:56	pass	MC	not detected by CrowdSport								
427.4	275.6	33:58	pass	MC	435.3	260.3	33:58	pass	MC	2.64m	0.1s	-	-
491.8	209.5	34:02	pass	MC	497.0	207.4	34:02	pass	MC	0.88m	0.1s	-	-
not in ground truth					458.1	211.5	34:03	pass	MC	not in ground truth			
437.3	262.8	34:04	pass	MC	442.5	248.4	34:04	pass	MC	2.35m	0.3s	-	-
408.8	319.8	34:06	pass	MC	415.5	317.8	34:06	pass	MC	1.11m	0.2s	-	-
398.9	417.3	34:08	pass	MC	419.7	359.6	34:08	pass	MC	9.41m	0.1s	-	-
284.9	319.8	34:09	pass	MC	not detected by CrowdSport								
131.3	300.8	34:18	pass	BW	127.5	285.8	34:18	pass	BW	2.37m	0.1s	-	-
462.1	224.0	34:22	intercept	MC	477.2	184.2	34:22	intercept	MC	6.53m	0.2s	-	-
462.1	224.0	34:22	pass	MC	not detected by CrowdSport								
209.4	267.7	34:37	intercept	BW	182.4	256.6	34:37	intercept	BW	4.60m	0.1s	-	-
204.4	259.5	34:37	pass	BW	212.8	241.8	34:38	pass	BW	3.01m	0.2s	-	-
234.1	235.9	34:39	pass	BW	not detected by CrowdSport								
249.0	279.3	34:40	pass	BW	257.2	235.3	34:40	pass	BW	6.86m	0.1s	-	-
298.6	246.3	34:41	intercept	MC	not detected by CrowdSport								
298.6	246.3	34:41	pass	MC	not detected by CrowdSport								
239.1	248.7	34:43	pass	MC	not detected by CrowdSport								

Evaluation: Test 1

Ground Truth					CrowdSport					Delta			
x	y	time	type	team	x	y	time	type	team	dist	time	type	team
293.6	274.4	33:54	pass	BW	287.8	263.0	33:54	pass	BW	1.96m	0.1s	-	-
457.1	347.5	33:56	intercept	MC	471.4	316.5	33:56	intercept	MC	5.25m	0.1s	-	-
457.1	347.5	33:56	pass	MC	not detected by CrowdSport								
427.4	275.6	33:58	pass	MC	435.3	260.3	33:58	pass	MC	2.64m	0.1s	-	-
491.8	209.5	34:02	pass	MC	497.0	207.4	34:02	pass	MC	0.88m	0.1s	-	-
<i>not in ground truth</i>					458.1	211.5	34:03	pass	MC	<i>not in ground truth</i>			
437.3	262.8	34:04	pass	MC	442.5	248.4	34:04	pass	MC	2.35m	0.3s	-	-
408.8	319.8	34:06	pass	MC	415.5	317.8	34:06	pass	MC	1.11m	0.2s	-	-
398.9	417.3	34:08	pass	MC	419.7	359.6	34:08	pass	MC	9.41m	0.1s	-	-
284.9	319.8	34:09	pass	MC	not detected by CrowdSport								
131.3	300.8	34:18	pass	BW	127.5	285.8	34:18	pass	BW	2.37m	0.1s	-	-
462.1	224.0	34:22	intercept	MC	477.2	184.2	34:22	intercept	MC	6.53m	0.2s	-	-
462.1	224.0	34:22	pass	MC	not detected by CrowdSport								
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204.4	259.5	34:37	pass	BW	212.8	241.8	34:38	pass	BW	3.01m	0.2s	-	-
234.1	235.9	34:39	pass	BW	not detected by CrowdSport								
249.0	279.3	34:40	pass	BW	257.2	235.3	34:40	pass	BW	6.86m	0.1s	-	-
298.6	246.3	34:41	intercept	MC	not detected by CrowdSport								
298.6	246.3	34:41	pass	MC	not detected by CrowdSport								
239.1	248.7	34:43	pass	MC	not detected by CrowdSport								

Evaluation: Test 1

Ground Truth					CrowdSport					Delta			
x	y	time	type	team	x	y	time	type	team	dist	time	type	team
293.6	274.4	33:54	pass	BW	287.8	263.0	33:54	pass	BW	1.96m	0.1s	-	-
457.1	347.5	33:56	intercept	MC	471.4	316.5	33:56	intercept	MC	5.25m	0.1s	-	-
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491.8	209.5	34:02	pass	MC	497.0	207.4	34:02	pass	MC	0.88m	0.1s	-	-
<i>not in ground truth</i>					458.1	211.5	34:03	pass	MC	<i>not in ground truth</i>			
437.3	262.8	34:04	pass	MC	442.5	248.4	34:04	pass	MC	2.35m	0.3s	-	-
408.8	319.8	34:06	pass	MC	415.5	317.8	34:06	pass	MC	1.11m	0.2s	-	-
398.9	417.3	34:08	pass	MC	419.7	359.6	34:08	pass	MC	9.41m	0.1s	-	-
284.9	319.8	34:09	pass	MC	not detected by CrowdSport								
131.3	300.8	34:18	pass	BW	127.5	285.8	34:18	pass	BW	2.37m	0.1s	-	-
462.1	224.0	34:22	intercept	MC	477.2	184.2	34:22	intercept	MC	6.53m	0.2s	-	-
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298.6	246.3	34:41	intercept	MC	not detected by CrowdSport								
298.6	246.3	34:41	pass	MC	not detected by CrowdSport								
239.1	248.7	34:43	pass	MC	not detected by CrowdSport								



Evaluation: Test 1

Ground Truth					CrowdSport					Delta			
x	y	time	type	team	x	y	time	type	team	dist	time	type	team
293.6	274.4	33:54	pass	BW	287.8	263.0	33:54	pass	BW	1.96m	0.1s	-	-
457.1	347.5	33:56	intercept	MC	471.4	316.5	33:56	intercept	MC	5.25m	0.1s	-	-
457.1	347.5	33:56	pass	MC	not detected by CrowdSport								
427.4	275.6	33:58	pass	MC	435.3	260.3	33:58	pass	MC	2.64m	0.1s	-	-
491.8	209.5	34:02	pass	MC	497.0	207.4	34:02	pass	MC	0.88m	0.1s	-	-
not in ground truth					458.1	211.5	34:03	pass	MC	not in ground truth			
437.3	262.8	34:04	pass	MC	442.5	248.4	34:04	pass	MC	2.35m	0.3s	-	-
408.8	319.8	34:06	pass	MC	415.5	317.8	34:06	pass	MC	1.11m	0.2s	-	-
398.9	417.3	34:08	pass	MC	419.7	359.6	34:08	pass	MC	9.41m	0.1s	-	-
284.9	319.8	34:09	pass	MC	not detected by CrowdSport								
131.3	300.8	34:18	pass	BW	127.5	285.8	34:18	pass	BW	2.37m	0.1s	-	-
462.1	224.0	34:22	intercept	MC	477.2	184.2	34:22	intercept	MC	6.53m	0.2s	-	-
462.1	224.0	34:22	pass	MC	not detected by CrowdSport								
209.4	267.7	34:37	intercept	BW	182.4	256.6	34:37	intercept	BW	4.60m	0.1s	-	-
204.4	259.5	34:37	pass	BW	212.8	241.8	34:38	pass	BW	3.01m	0.2s	-	-
234.1	235.9	34:39	pass	BW	not detected by CrowdSport								
249.0	279.3	34:40	pass	BW	257.2	235.3	34:40	pass	BW	6.86m	0.1s	-	-
298.6	246.3	34:41	intercept	MC	not detected by CrowdSport								
298.6	246.3	34:41	pass	MC	not detected by CrowdSport								
239.1	248.7	34:43	pass	MC	not detected by CrowdSport								

Evaluation: Test 1

Ground Truth					CrowdSport					Delta			
x	y	time	type	team	x	y	time	type	team	dist	time	type	team
293.6	274.4	33:54	pass	BW	287.8	263.0	33:54	pass	BW	1.96m	0.1s	-	-
457.1	347.5	33:56	intercept	MC	471.4	316.5	33:56	intercept	MC	5.25m	0.1s	-	-
457.1	347.5	33:56	pass	MC	not detected by CrowdSport								
427.4	275.6	33:58	pass	MC	435.3	260.3	33:58	pass	MC	2.64m	0.1s	-	-
491.8	209.5	34:02	pass	MC	497.0	207.4	34:02	pass	MC	0.88m	0.1s	-	-
not in ground truth					458.1	211.5	34:03	pass	MC	not in ground truth			
437.3	262.8	34:04	pass	MC	442.5	248.4	34:04	pass	MC	2.35m	0.3s	-	-
408.8	319.8	34:06	pass	MC	415.5	317.8	34:06	pass	MC	1.11m	0.2s	-	-
398.9	417.3	34:08	pass	MC	419.7	359.6	34:08	pass	MC	9.41m	0.1s	-	-
284.9	319.8	34:09	pass	MC	not detected by CrowdSport								
131.3	300.8	34:18	pass	BW	127.5	285.8	34:18	pass	BW	2.37m	0.1s	-	-
462.1	224.0	34:22	intercept	MC	477.2	184.2	34:22	intercept	MC	6.53m	0.2s	-	-
462.1	224.0	34:22	pass	MC	not detected by CrowdSport								
209.4	267.7	34:37	intercept	BW	182.4	256.6	34:37	intercept	BW	4.60m	0.1s	-	-
204.4	259.5	34:37	pass	BW	212.8	241.8	34:38	pass	BW	3.01m	0.2s	-	-
234.1	235.9	34:39	pass	BW	not detected by CrowdSport								
249.0	279.3	34:40	pass	BW	257.2	235.3	34:40	pass	BW	6.86m	0.1s	-	-
298.6	246.3	34:41	intercept	MC	not detected by CrowdSport								
298.6	246.3	34:41	pass	MC	not detected by CrowdSport								
239.1	248.7	34:43	pass	MC	not detected by CrowdSport								
										mean: 3.91m stdev: 2.63m			



Evaluation: Test 1

Ground Truth					CrowdSport					Delta			
x	y	time	type	team	x	y	time	type	team	dist	time	type	team
293.6	274.4	33:54	pass	BW	287.8	263.0	33:54	pass	BW	1.96m	0.1s	-	-
457.1	347.5	33:56	intercept	MC	471.4	316.5	33:56	intercept	MC	5.25m	0.1s	-	-
457.1	347.5	33:56	pass	MC	not detected by CrowdSport								
427.4	275.6	33:58	pass	MC	435.3	260.3	33:58	pass	MC	2.64m	0.1s	-	-
491.8	209.5	34:02	pass	MC	497.0	207.4	34:02	pass	MC	0.88m	0.1s	-	-
not in ground truth					458.1	211.5	34:03	pass	MC	not in ground truth			
437.3	262.8	34:04	pass	MC	442.5	248.4	34:04	pass	MC	2.35m	0.3s	-	-
408.8	319.8	34:06	pass	MC	415.5	317.8	34:06	pass	MC	1.11m	0.2s	-	-
398.9	417.3	34:08	pass	MC	419.7	359.6	34:08	pass	MC	9.41m	0.1s	-	-
284.9	319.8	34:09	pass	MC	not detected by CrowdSport								
131.3	300.8	34:18	pass	BW	127.5	285.8	34:18	pass	BW	2.37m	0.1s	-	-
462.1	224.0	34:22	intercept	MC	477.2	184.2	34:22	intercept	MC	6.53m	0.2s	-	-
462.1	224.0	34:22	pass	MC	not detected by CrowdSport								
209.4	267.7	34:37	intercept	BW	182.4	256.6	34:37	intercept	BW	4.60m	0.1s	-	-
204.4	259.5	34:37	pass	BW	212.8	241.8	34:38	pass	BW	3.01m	0.2s	-	-
234.1	235.9	34:39	pass	BW	not detected by CrowdSport								
249.0	279.3	34:40	pass	BW	257.2	235.3	34:40	pass	BW	6.86m	0.1s	-	-
298.6	246.3	34:41	intercept	MC	not detected by CrowdSport								
298.6	246.3	34:41	pass	MC	not detected by CrowdSport								
239.1	248.7	34:43	pass	MC	not detected by CrowdSport								
										mean: 0.14s stdev: 0.07s			

Evaluation: Test

Summary II

- > 1 false positive
(event detected by CrowdSport but not existent in ground truth)
- > 7 false negative
(event existent in ground truth but not detected by CrowdSport)
2 of the false negatives due to events happening simultaneously (intercept - pass)
- > position off by 3.91m on average
- > time off by 0.14s on average
- > no errors in type of event and team
- > similar results for other tests

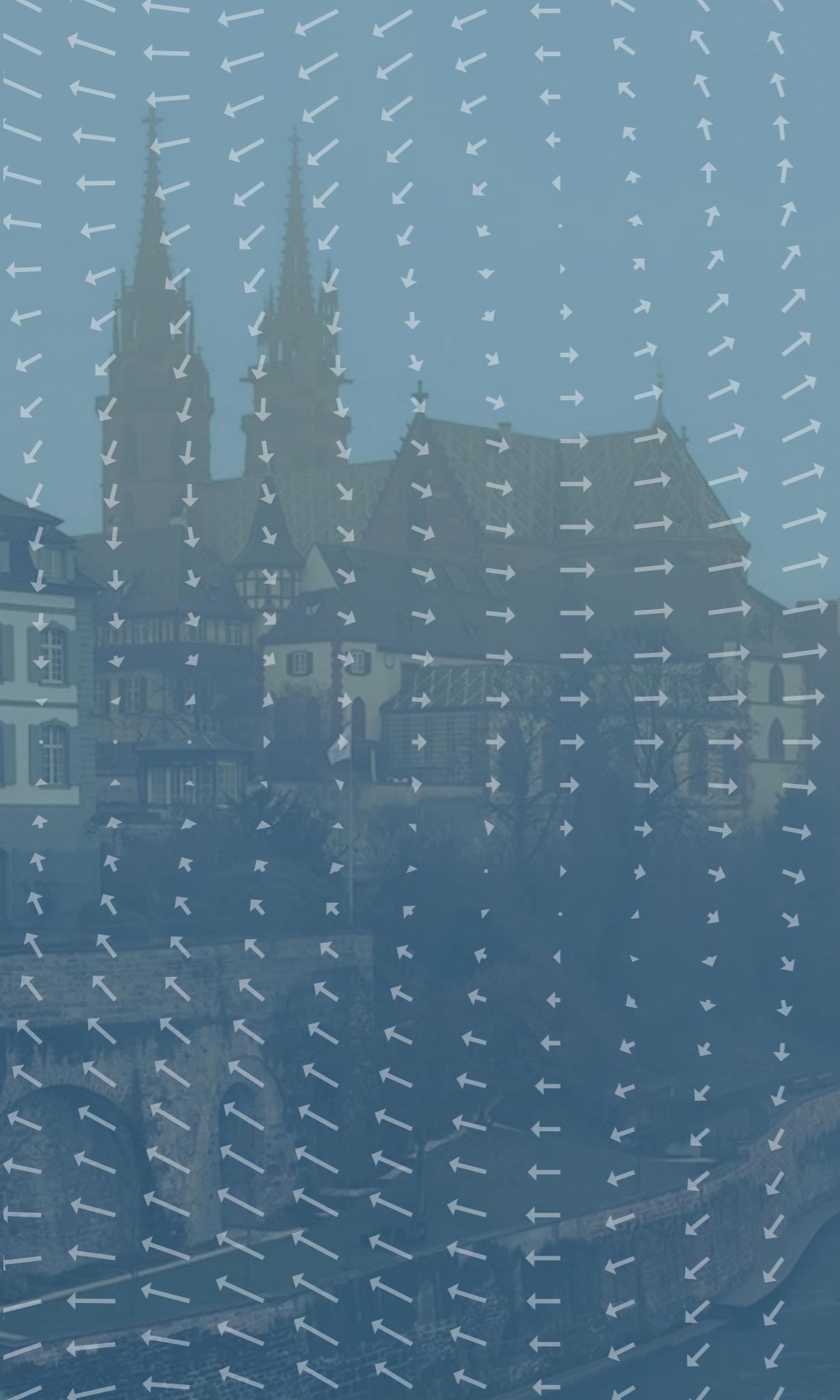
Lessons Learned

Assessing the user is indispensable.

Avoid ambiguous and complex tasks.

Conclusions and Outlook

- › CrowdSport: leverage the wisdom of the crowd to identify semantic events in soccer videos
- › assessment and rating indispensable for reaching a high(er) quality of the data
- › useful results in scenes that are not overly complex
- › more work necessary on the refinement of the system (assess user more often, improvements in integration and cleaning step, etc.)
- › possibly a combination of crowd sourcing together with computer vision/sensor data is necessary



Questions

@dbisUnibas

Acknowledgements

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