

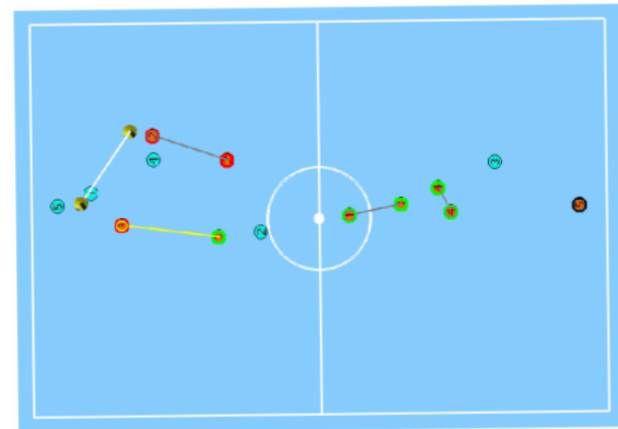
The logo for TU/e Tech United Eindhoven is a shield-shaped emblem. It features a grey gear-like border at the top. Inside the shield, the words "TECH UNITED" are written in a stylized, blocky font, with "TECH" in white and "UNITED" in grey. Below this, "EINDHOVEN" is written in orange. At the bottom of the shield, there is a green and white soccer ball. The entire logo is set against a dark green background.

Learning behavior of opponent teams

Goal of the work



- To learn the behavior of Opponent Teams
- Behavior of 4 field players for games of a given year
- Work in progress
 - Currently building tools
 - Analyzing log files
 - Studying OO Neural Nets
- Use the Turtle logfiles to identify:
 - Game Situations
 - Team Formations
 - Player Actions



Learning in Robotics



- Simulation League and SSL
 - 3D – Mostly Low Level Control like walking
 - 2D – Mostly tactics
 - SSL – Mostly tactics
- Most robotics learning programs concentrate on low-level learning
 - Motor Control
 - Dribbling with the ball
- Aim for learning Opponent Behaviors:
 - Game Situation Classification
 - Role and Action analysis
 - Finding similar situations
 - Learning situation-based behavior
 - Learning on symbolic level

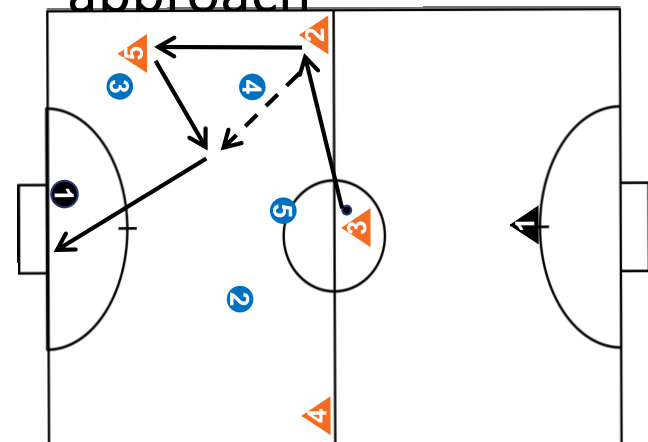
Learning Behaviors



- Using Futsal Coaching Manuals of:
 - FIFA, UEFA
 - KNVB coach Max Tjaden
- Learning in terms of Futsal Set-Pieces

- Learning on Symbolic Level

- Being able to explain behaviors
- Basis for a more general approach

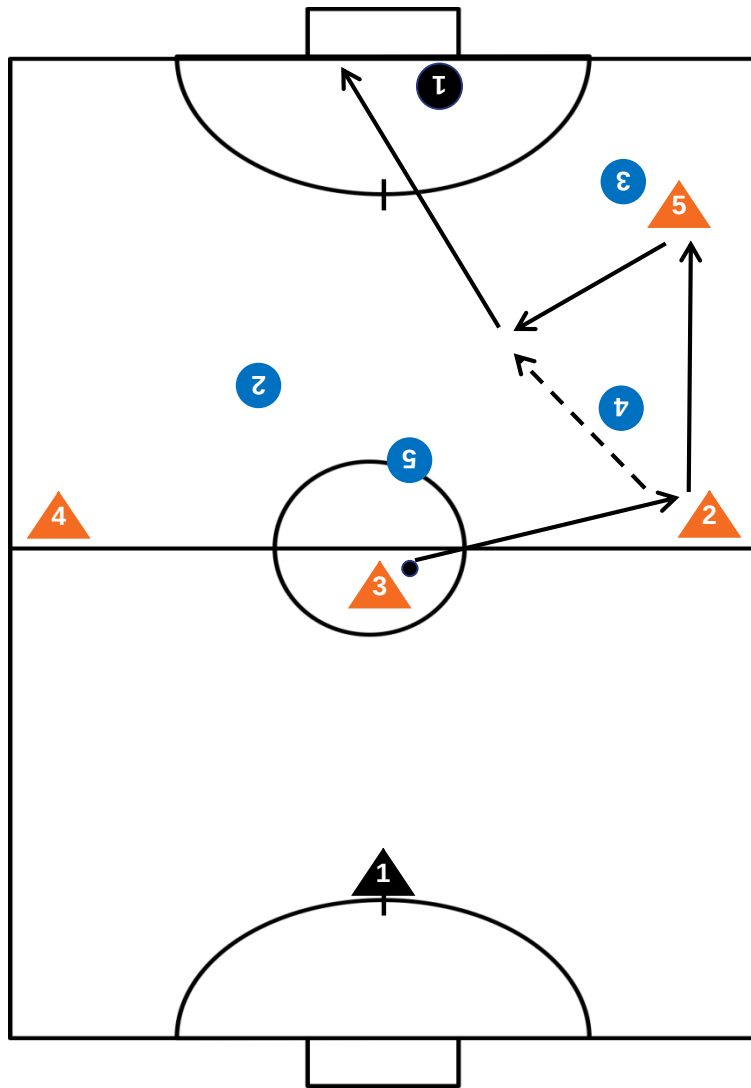




AANVALLEN

OPBOUWEN – HELFT
TEGENPARTIJ

3^E MAN



AANVALLEN – OPBOUWEN – HTP

3^e MAN

Teamfunctie:

Aanvallen

Teamtaak:

Opbouwen

Speelveldgedeelte:

Helft tegenpartij

Rol tegenpartij:

Klein op eigen helft

Kwaliteit van handelen

3 speelt de bal op 2

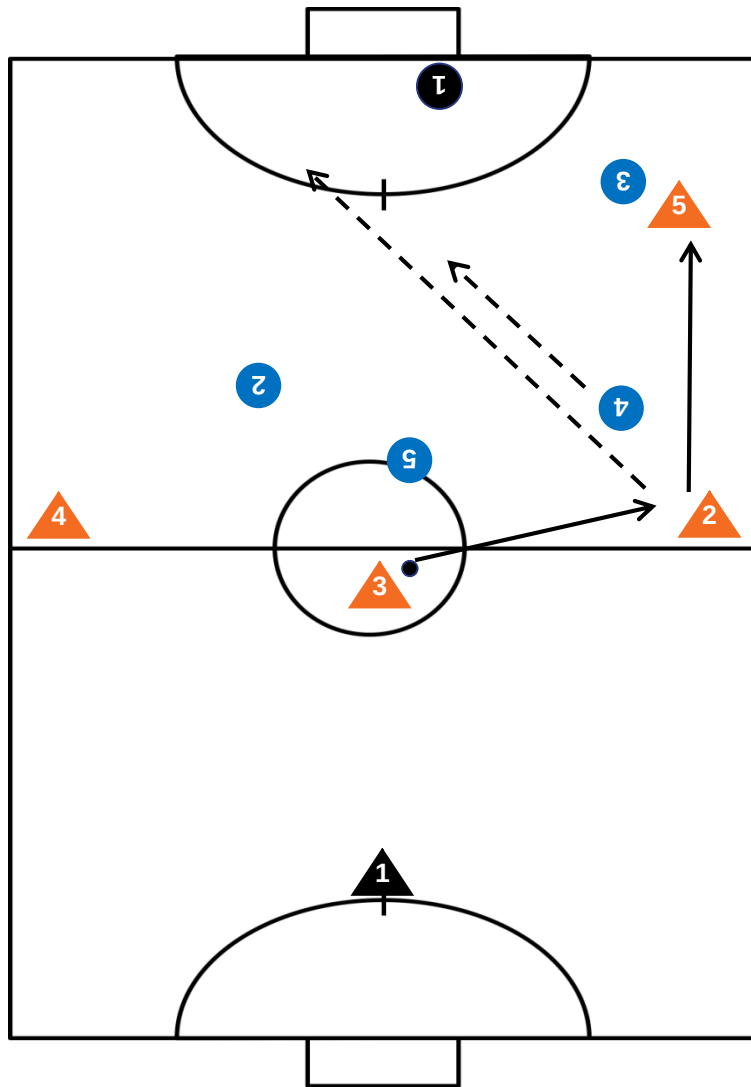
2 speelt de bal door op 5

2 loopt schuin weg

5 geeft de bal mee aan 2 (1-2 tje)

*Afstemmen van handelen zonder bal en met bal tussen 5 2
(= communicatie)*

Moment/snelheid/richting/positie schuin weglopen en passen



AANVALLEN – OPBOUWEN – HTP

3^e MAN

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Kwaliteit van handelen

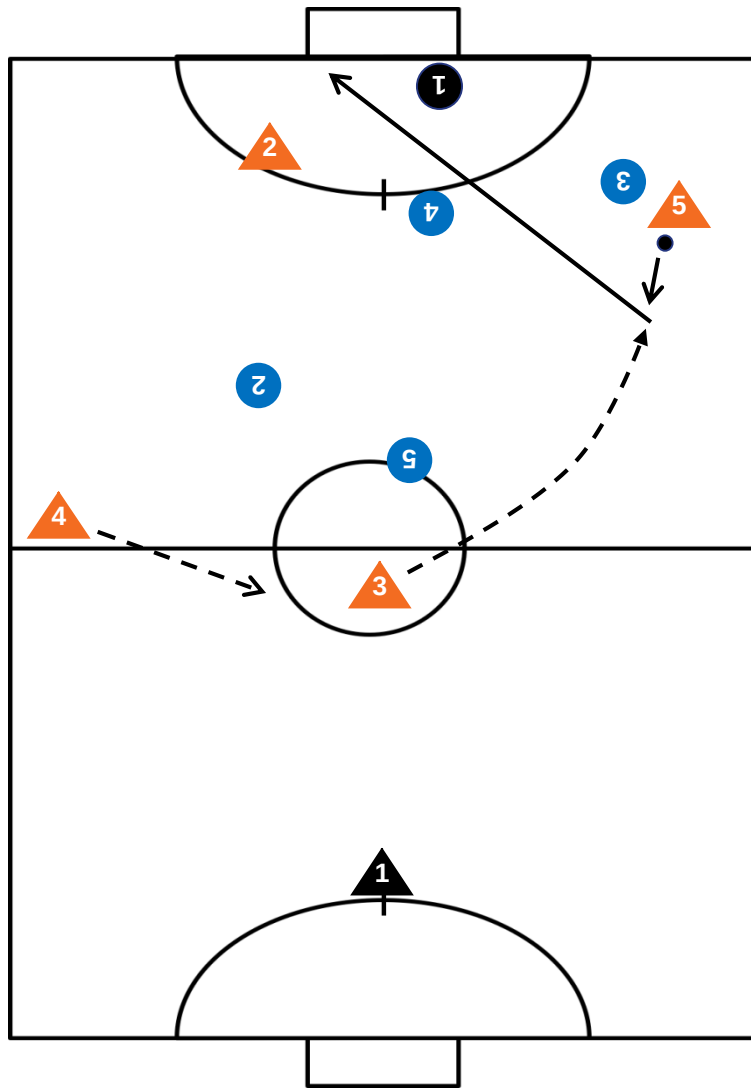
5 legt de bal terug op 3

3 schiet op doel

*Afstemmen van handelen zonder bal en met bal tussen
(= communicatie)*



Moment/snelheid/richting/schuin weglopen en passen



3^e MAN

Aanvallen

Opbouwen

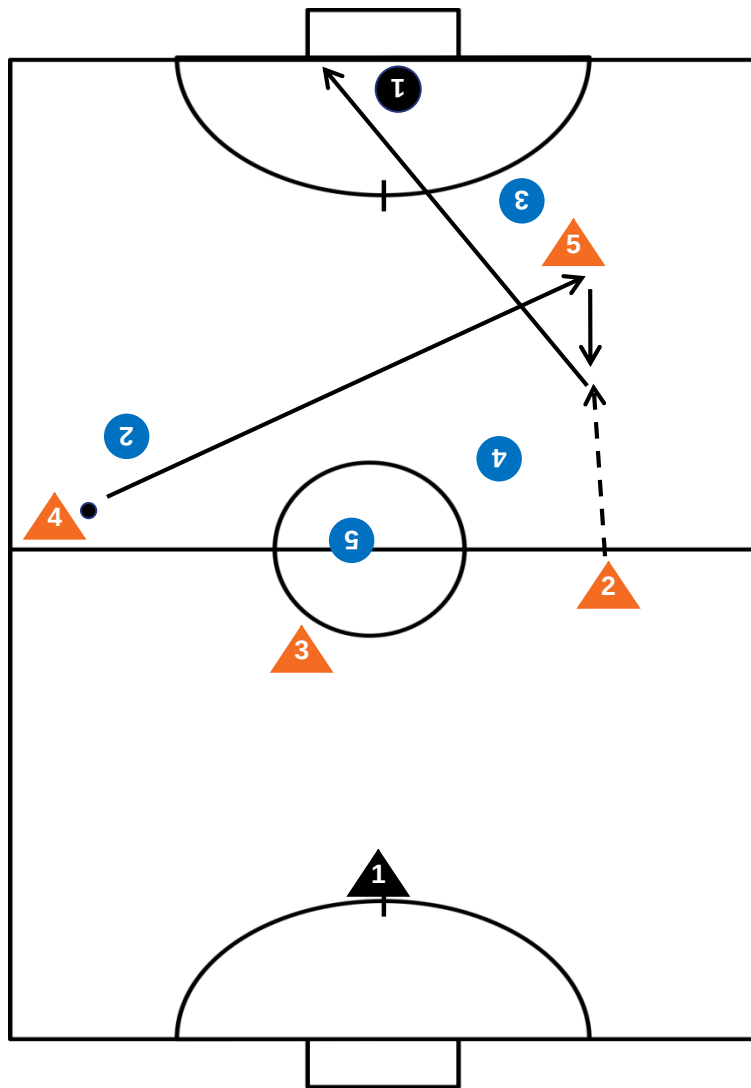
Helft tegenpartij

Klein op eigen helft

- 3 speelt de bal op 2
- 2 speelt de bal door op 5
- 2 zorgt voor de rest-verdediging

Afstemmen van handelen zonder bal en met bal tussen 5 3
(= communicatie)

Moment/snelheid/richting/positie vast houden van de bal en er “onder” komen



AANVALLEN – OPBOUWEN – HTP

3^e MAN

Teamfunctie:

Aanvallen

Teamtaak:

Opbouwen

Speelveldgedeelte:

Helft tegenpartij

Rol tegenpartij:

Klein op eigen helft

Kwaliteit van handelen

4 speelt de bal diagonaal op 5

2 sluit bij, bij 5

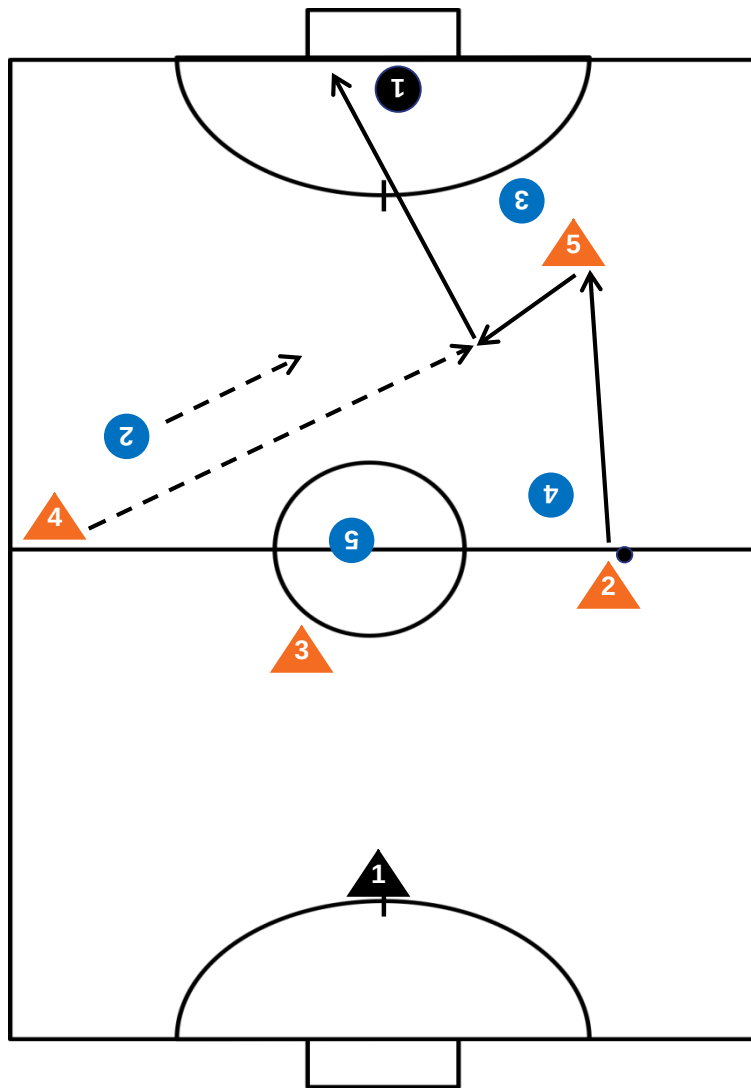
5 legt de bal terug op 2

2 schiet op doel

*Afstemmen van handelen zonder bal en met bal tussen
(= communicatie)*



*Moment/snelheid/richting/positie passen, bijsluiten, terugrollen en
schieten*



3^e MAN

Aanvallen

Opbouwen

Helft tegenpartij

Klein op eigen helft

Kwaliteit van handelen

4 schiet op doel

2 5 4

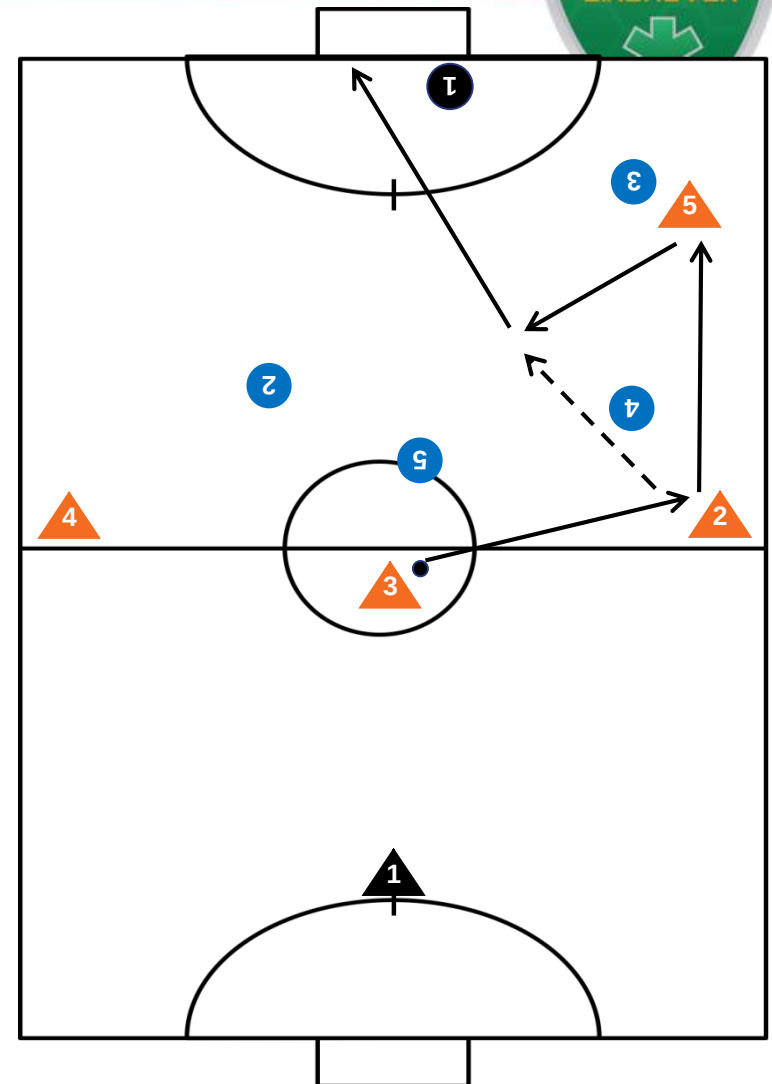
Moment/snelheid/richting/positie passen, bijsluiten, terugleggen en schieten



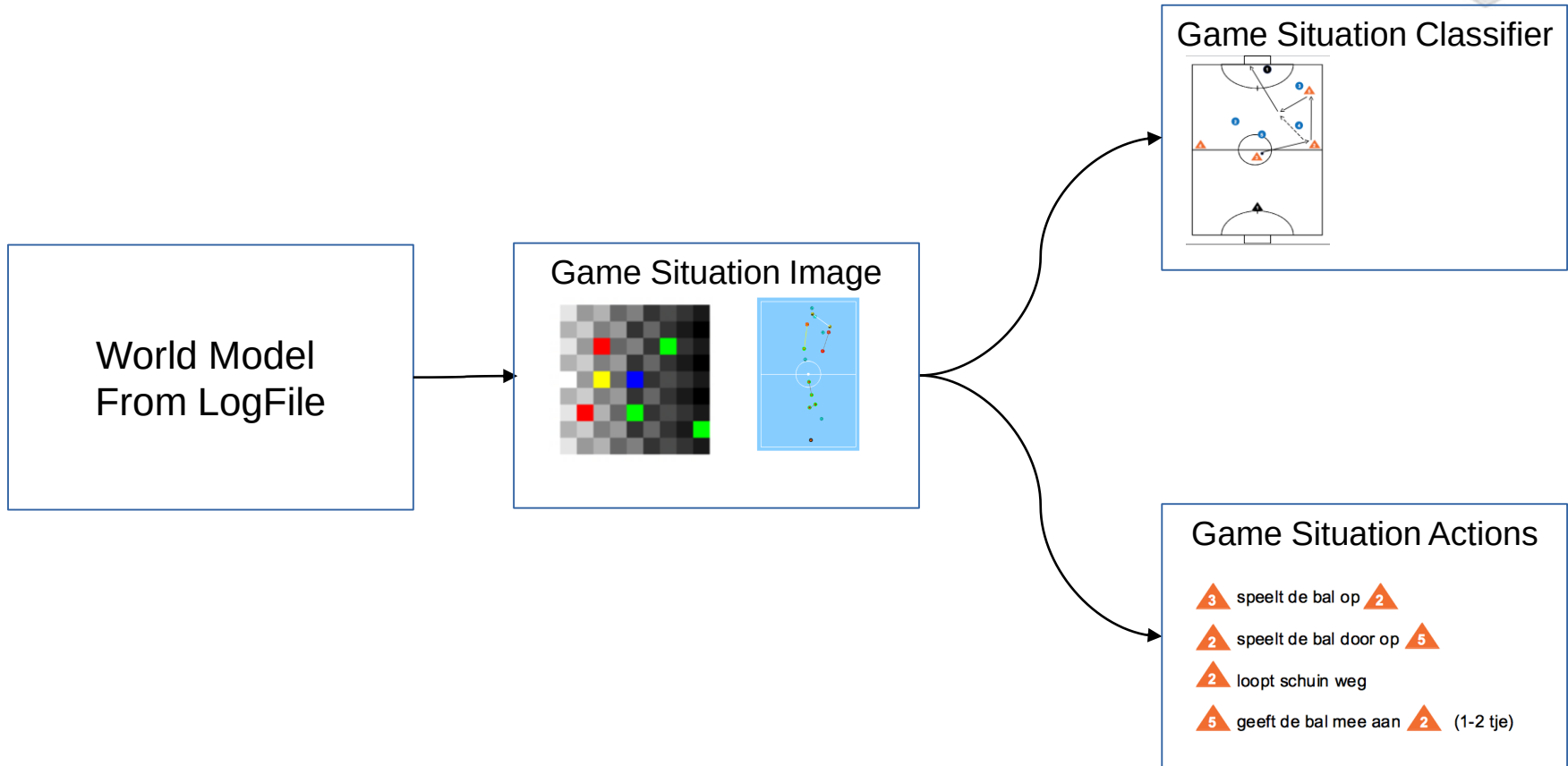
Determining Game Situations



- Use player positions to determine pattern
- Determine playing half
- Find all variations of this game situation
- Identify game situation for team and per player



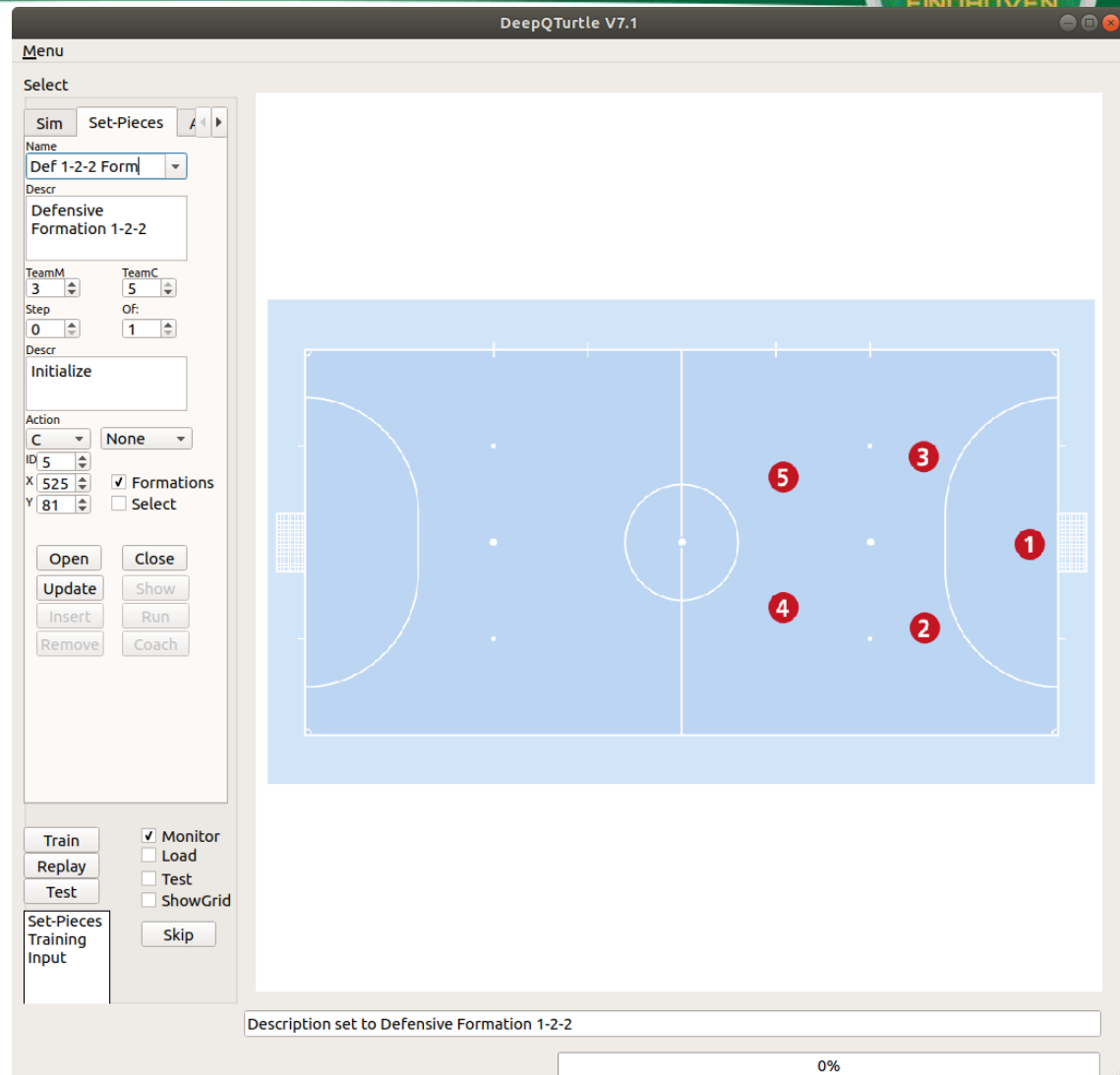
Learning Model



SetPiece Formation (1-2-2)



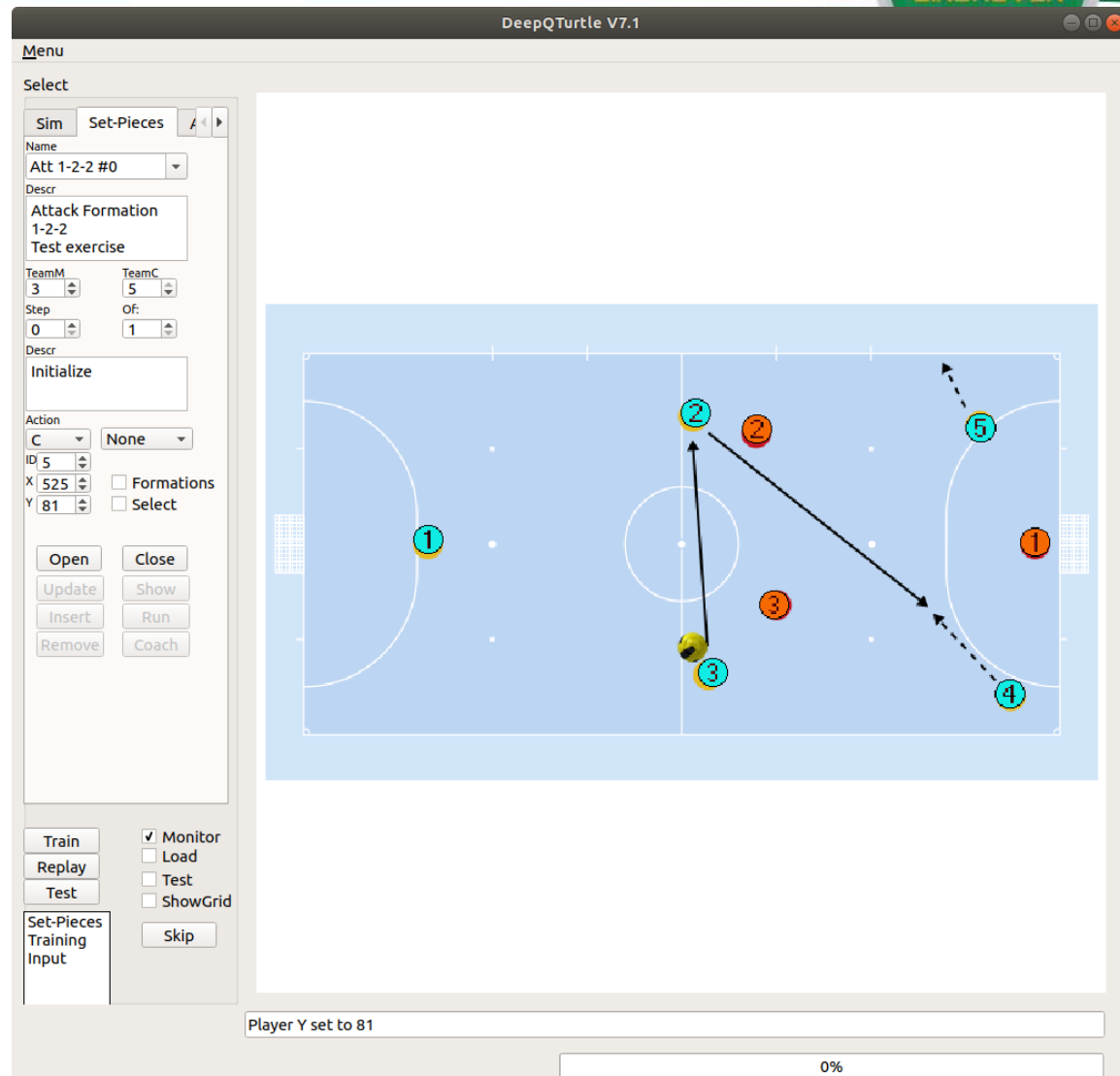
- Set-Pieces are organized around Formations
- Each player has a role in a formation
- Formations are dynamic



SetPiece Editor



- Enter a Set-Piece
- Enter every step
- Show Actions per step
- To be generated from the learned model



Loading the logfile



- RefBox Situations
 - Only use steps from Start to Stop
 - Draw lines between first and last step
 - Show Role and Action for each Robot
- Game Situations
 - AOWAMD
 - DTSAMD
 - Show all Game Situations and statistics
- Show steps of selected episodes
 - Scroll or step
 - Visual representation

DeepQTurtle V7.1

Menu

Select

Sim Set-Pieces / >

TeamM 1 TeamC 0 VOF 3 Scale 0 Ep=0 0 Stp=0 0

Replay M 1 10

MatLab File FALCONS saturday 1.r

Stop Search

AOS202 U T B

Step SetPiece/GSI Info Formations

Own/Opp Show FormID

Load Export Analyze Classify Play

Steps 1 E: 11018 12 134

World Model -1

R G B

Train Replay Test

Set-Pieces Training Input

Monitor Load Test ShowGrid Skip

RefBox	Start	Stc
1 Throwin Magenta	0	12
2 Start	12	134
3 Stop	134	386
4 GoalKick Cyan	386	516
5 Start	516	592
6 Stop	592	677
7 Dropped Ball	677	696
8 Stop	696	982
9 FreeKick Magenta	982	106

Form	#	%	Steps
1 UOW112	3	1.2	13.0
2 DOW103	1	0.4	37.0
3 AOS112	2	0.8	14.5
4 AOS103	1	0.4	25.0
5 AOW103	1	0.4	2.0
6 UTS121	2	0.8	7.5
7 ATS211	3	1.2	7.66
8 DOS103	2	0.8	17.0
9 AOW121	2	0.8	13.0

DefCon	Start	Stop	Steps	ID
1 AOS202	12	96	84	
2 DOS202	96	98	2	
3 AOS202	98	99	1	
4 DOS202	99	105	6	
5 AOS202	105	110	5	
6 DOS202	110	112	2	
7 AOS202	112	115	3	
8 DOS202	115	133	18	

Events: 11018 Size: 1446 Turtle: 206.42857142857142

0%

Find similar Game Situations



- GameSit
AOS211
- Find all episodes with the same GameSit
- Basis to find Agent GameSit for comparable situations

DeepQTurtle V7.1

Menu

Select

Sim Set-Pieces /

TeamM 1

TeamC 0

VOF 3

Scale 0

Ep=0

Stp=0

MatLab File

FALCONS saturday 1.r

Stop

AOS211

U T B

Image

Step

SetPiece/GSI

Info

Formations

Own/Opp

Show

FormID

Load

Export

Analyze

Classify

Play

Steps

1

E: 11018

5101

5120

World Model

-1

R G B

Monitor

Load

Test

ShowGrid

Skip

Set-Pieces Training Input

RefBox	Start	Stc
1 Throwin Magenta	0	12
2 Start	12	134
3 Stop	134	386
4 GoalKick Cyan	386	516
5 Start	516	592
6 Stop	592	677
7 Dropped Ball	677	696
8 Stop	696	982
9 FreeKick Magenta	982	106

Form	#	%	Steps
1 DOS211	16	6.8	9.01
2 AOS211	13	5.5	7.66
3 DOS202	12	5.1	14.72
4 AOS121	11	4.7	10.25
5 AOS202	11	4.7	25.98
6 DOW202	9	3.8	19.98
7 UOS121	8	3.4	11.24
8 AOW202	7	2.9	40.27
9 DOW211	7	2.9	19.13

Form	#	%	Steps	IC
1 AOS211	1638	1642	4	
2 AOS211	1680	1684	4	
3 AOS211	3851	3860	9	
4 AOS211	5101	5120	19	
5 AOS211	6285	6313	28	
6 AOS211	7009	7015	6	
7 AOS211	7017	7021	4	
8 AOS211	8062	8066	4	
9 AOS211	8695	8697	2	
10 AOS211	8701	8703	2	

SetPiece	Start	Stop	Steps
1 KDDAA	5101	5120	19

Events: 11018 Size: 1446 Turtle: 206.42857142857142

0%

Search Similar Actions



- Find Passes
- Show entire episode
- Browse through steps before and after
- Analyze when a pass is initiated
- Who is the receiver

DeepQTurtle V7.1

Menu

Select

Sim Set-Pieces /

TeamM 1 TeamC 0 VOF 3 Scale 0 Ep=0 0 Stp=0 0

MatLab File FALCONS saturday 1.r

Pass ATW301

☐ Step ☐ SetPiece/GSI ☐ Info ☐ Formations ☒ Own/Opp ☒ Show ☒ FormID

Steps 1 E: 11018 2543 2564

World Model -1

☒ R ☒ G ☒ B

Train Replay Test

Set-Pieces Training Input

RefBox

	RefBox	Start	Stc
1	ThrowIn Magenta	0	12
2	Start	12	134
3	Stop	134	386
4	GoalKick Cyan	386	516
5	Start	516	592
6	Stop	592	677
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8	Stop	696	982
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4	AOS103	1	0.4	25.0
5	AOW103	1	0.4	2.0
6	UTS121	2	0.8	7.5
7	ATS211	3	1.2	7.66
8	DOS103	2	0.8	17.0
9	AOW121	2	0.8	13.0

Pass Start Stop Steps ID

1	ATW301	2543	2564	21	6.2
2	ATS112	3747	3803	56	3.2
3	ATS112	3778	3803	25	6.2
4	AOW202	9112	9124	12	4.2

SetPiece Start Stop Steps

1	KDADA	2543	2544	1
2	KAADA	2544	2545	1
3	KADDA	2545	2547	2
4	KDADA	2547	2548	1
5	KADDA	2548	2549	1
6	KDADA	2549	2554	5
7	KDDDA	2554	2555	1
8	KADDA	2555	2556	1
9	KDADA	2556	2557	1
10	KADDA	2557	2561	4
11	KAADA	2561	2562	1

Events: 11018 Size: 1446 Turtle: 206.42857142857142

0%

Show Pass GSI



- Show Pass GSI
- Show ASI for each agent
- Attention Network
 - Input
 - Seq2Seq Transformer
 - GSI, ASI, RoleID
 - Game Situation
 - Output
 - Role
 - Intention
 - Action

DeepQTurtle V7.1

Menu

Select

Sim Set-Pieces

TeamM 1 TeamC 0 VOF 3 Scale 0 Ep=0 Stp=0

Replay

M ID 1 Freq 10

MatLab File

FALCONS saturday 1.r

Pass Search

AOW202 U T B

Step

SetPiece/GSI

Info

Formations

Own/Opp

Show

FormID

Load

Export

Analyze

Classify

Play

Steps 1

E: 11018

9112

9124

World Model -1

R G B

Train

Replay

Test

Set-Pieces Training Input

Monitor

Load

Test

ShowGrid

Skip

RefBox

	RefBox	Start	Stop	Steps
1	ThrowIn Magenta	0	12	12
2	Start	12	134	134
3	Stop	134	386	386
4	GoalKick Cyan	386	516	516
5	Start	516	592	592
6	Stop	592	677	677
7	Dropped Ball	677	696	696
8	Stop	696	982	982
9	FreeKick Magenta	982	106	106

Form # % Steps

	Form	#	%	Steps
1	DOS211	16	6.8	9.01
2	AOS211	13	5.5	7.66
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Pass Start Stop Steps ID

	Pass	Start	Stop	Steps	ID
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3	ATS112	3778	3803	25	6,2
4	AOW202	9112	9124	12	4,2

SetPiece Start Stop Steps

	SetPiece	Start	Stop	Steps
1	KADAD	9112	9114	2
2	KADDD	9114	9115	1
3	KAADD	9115	9117	2
4	KDAAD	9117	9118	1
5	KAADD	9118	9120	2
6	KDAAD	9120	9122	2
7	KADDA	9122	9124	2

AttNetwork

ASI GRU GRU GRU

GameSit

All

Role

Role

Intention

Intention

Action

Action

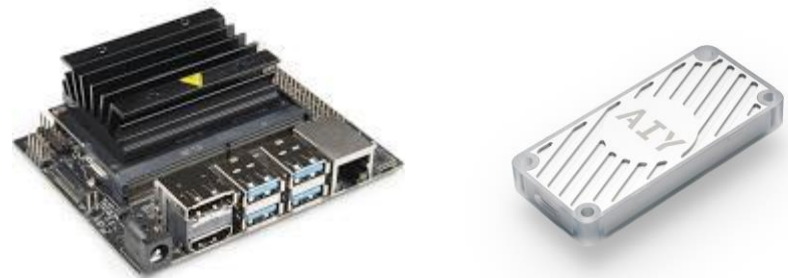
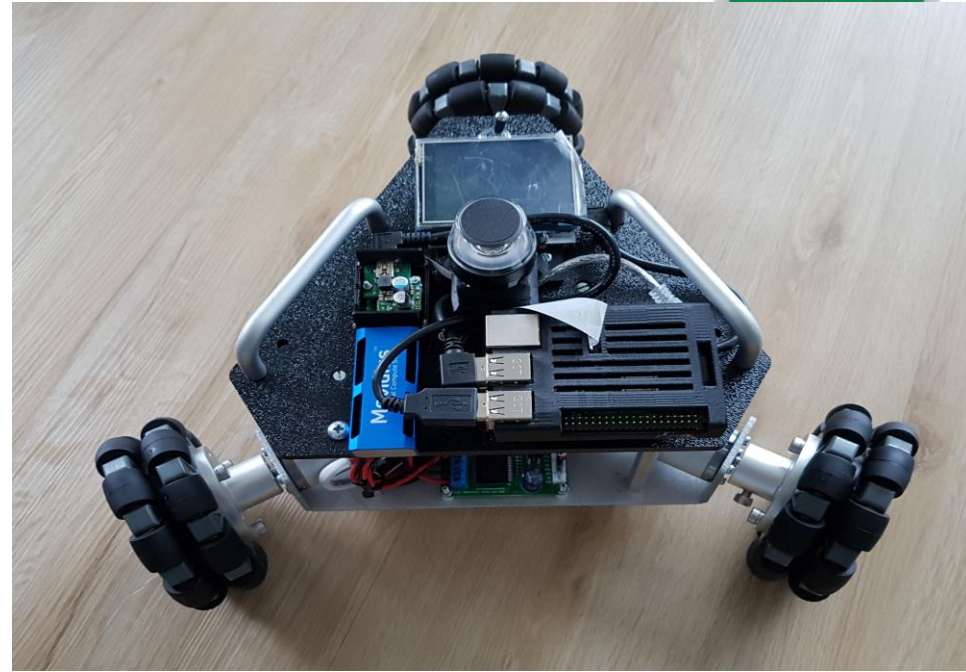
SimGSI set to True

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Hardware Implementation



- Follow-up project
- Mini Turtle test
- Jetson Nano and Google Edge TPU
- Continual Learning
 - Recognize ball
 - Learn to dribble
 - Learn to avoid obstacles



Highlights



- Speed / Size in embedded systems
- What does a Neural Network do
 - Explanation Facilities:
 - Why / How
 - Visualization
- NO end-to-end learning
 - Hybrid between conventional and Machine Learning
- Learning vs Teaching
- Operational Constraints
 - No massive GPU and CPU intense solutions

