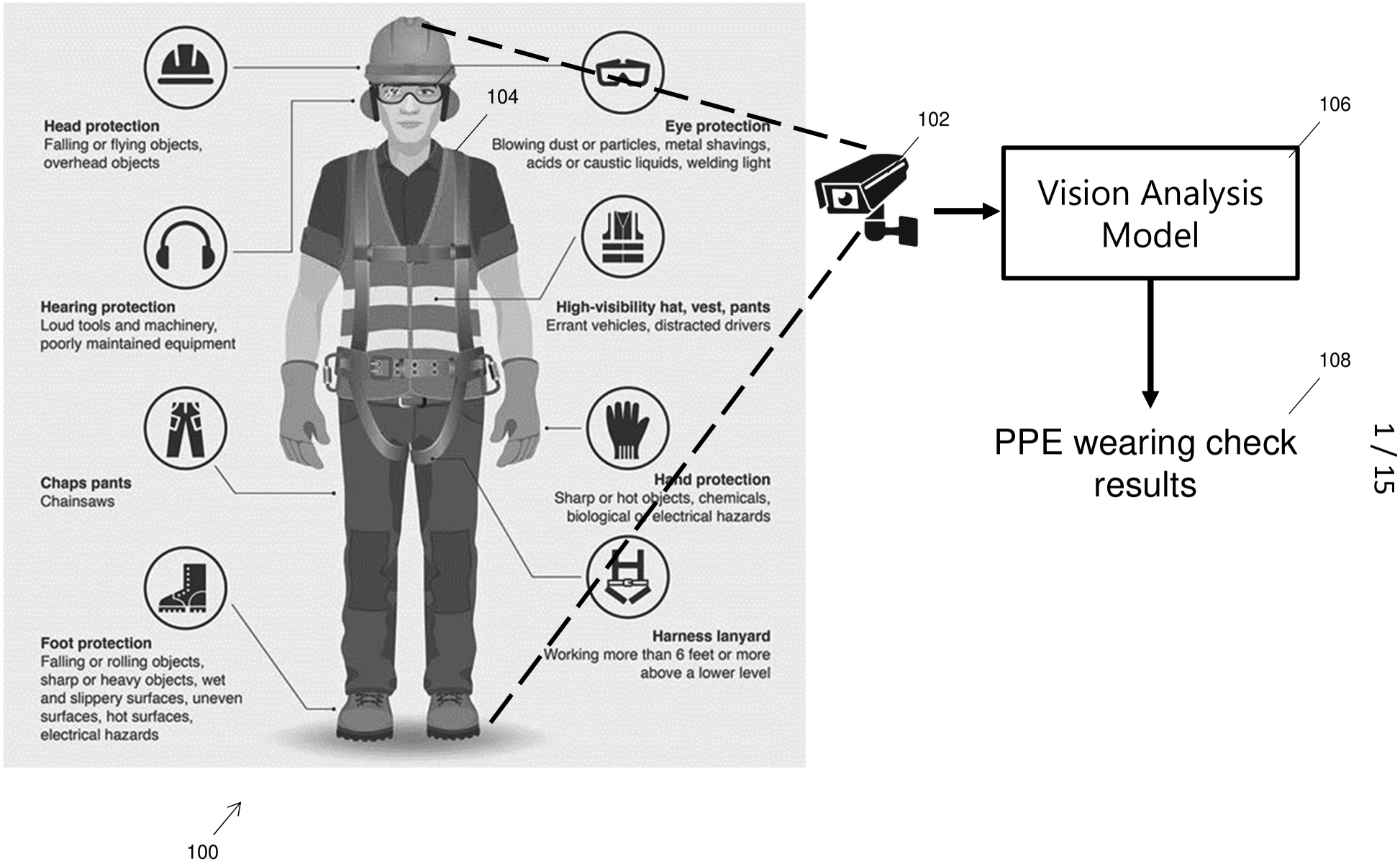

Head protection
Falling or flying objects, overhead objects
Eye protection
Blowing dust or particles, metal shavings, acids or caustic liquids, welding light
Hearing protection
Loud tools and machinery, poorly maintained equipment
High-visibility hat, vest, pants
Errant vehicles, distracted drivers
Chaps pants
Chainsaws
Hand protection
Sharp or hot objects, chemicals, biological or electrical hazards
Foot protection
Falling or rolling objects, sharp or heavy objects, wet and slippery surfaces, uneven surfaces, hot surfaces, electrical hazards
Harness lanyard
Working more than 6 feet or more above a lower level
104
102
106
Vision Analysis Model
108
PPE wearing check results
100

Figure 1

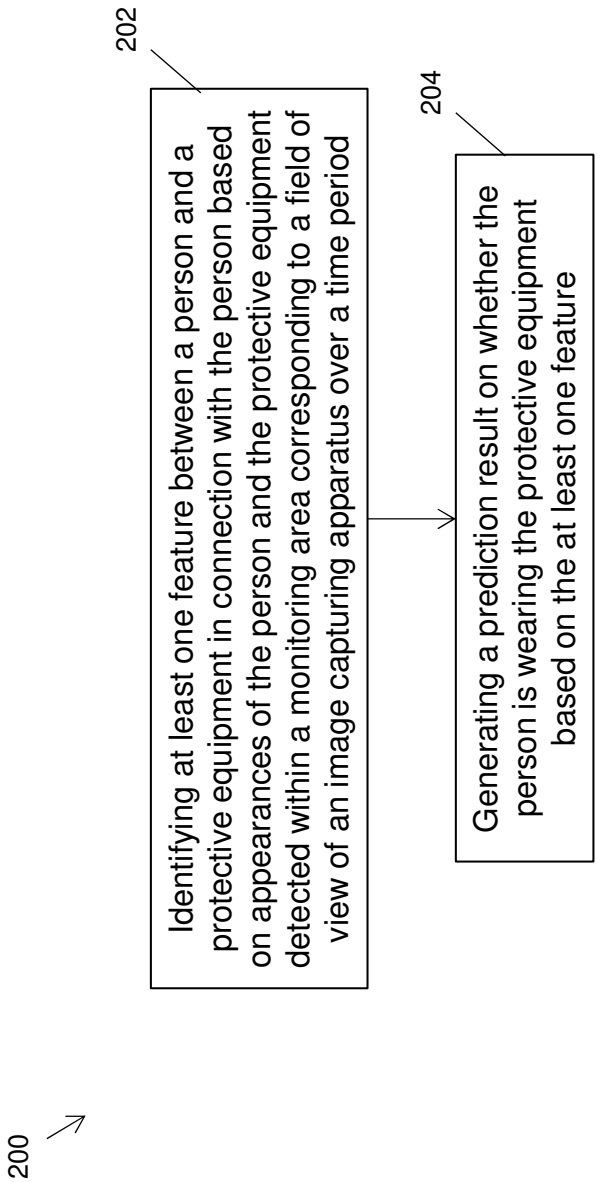

200
202
Identifying at least one feature between a person and a protective equipment in connection with the person based on appearances of the person and the protective equipment detected within a monitoring area corresponding to a field of view of an image capturing apparatus over a time period
204
Generating a prediction result on whether the person is wearing the protective equipment based on the at least one feature

Figure 2

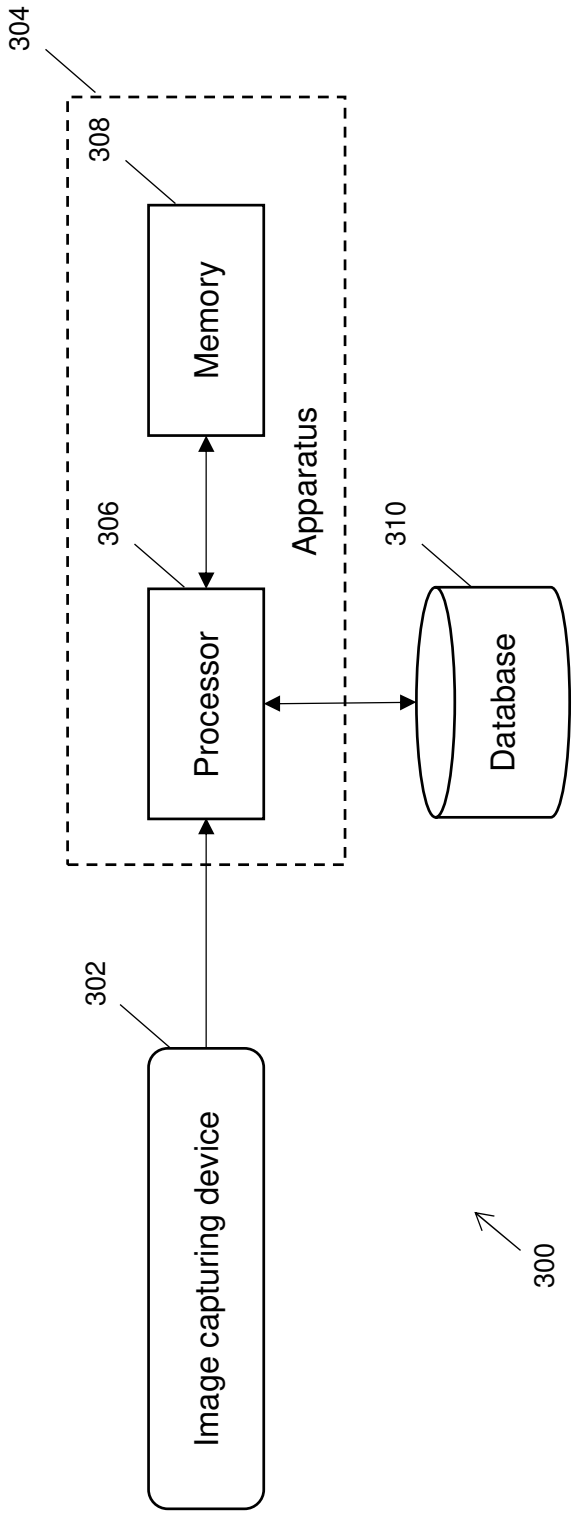

304
308
Memory
Apparatus
306
310
Processor
Database
302
Image capturing device
300

Figure 3

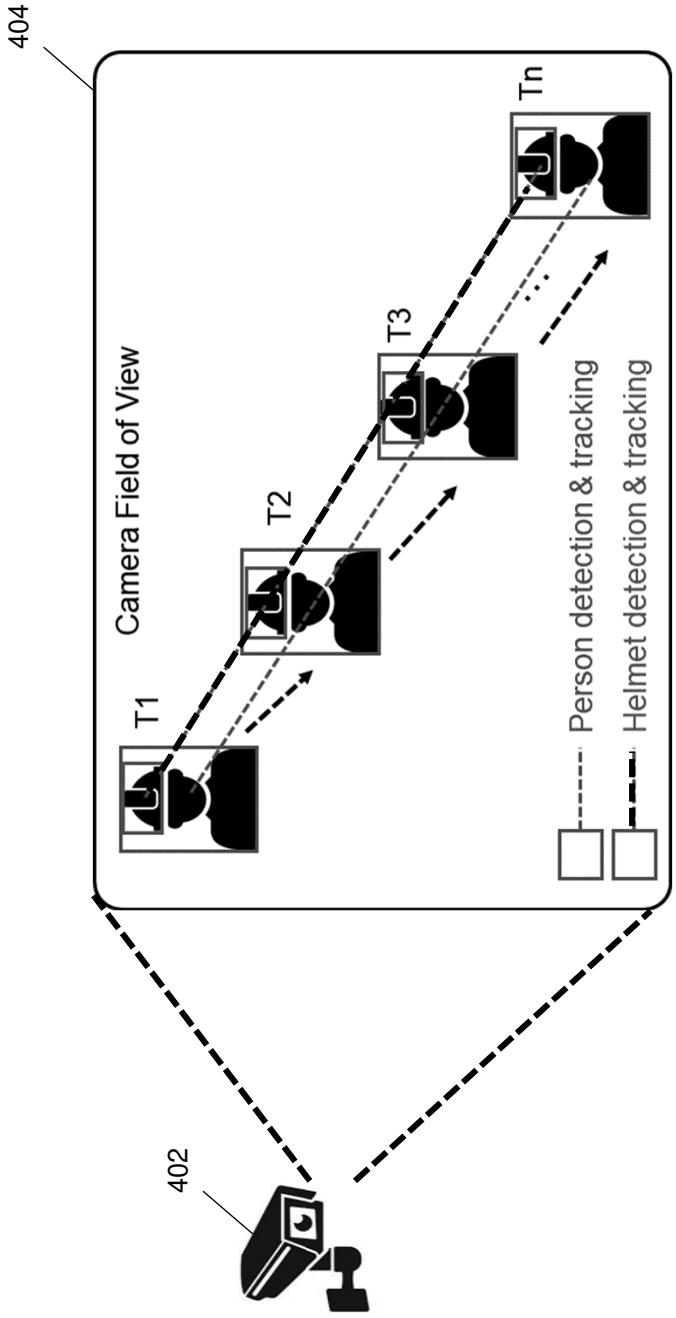

404
Camera Field of View
T1
T2
T3
Tn
Person detection & tracking
Helmet detection & tracking
402
400

Figure 4

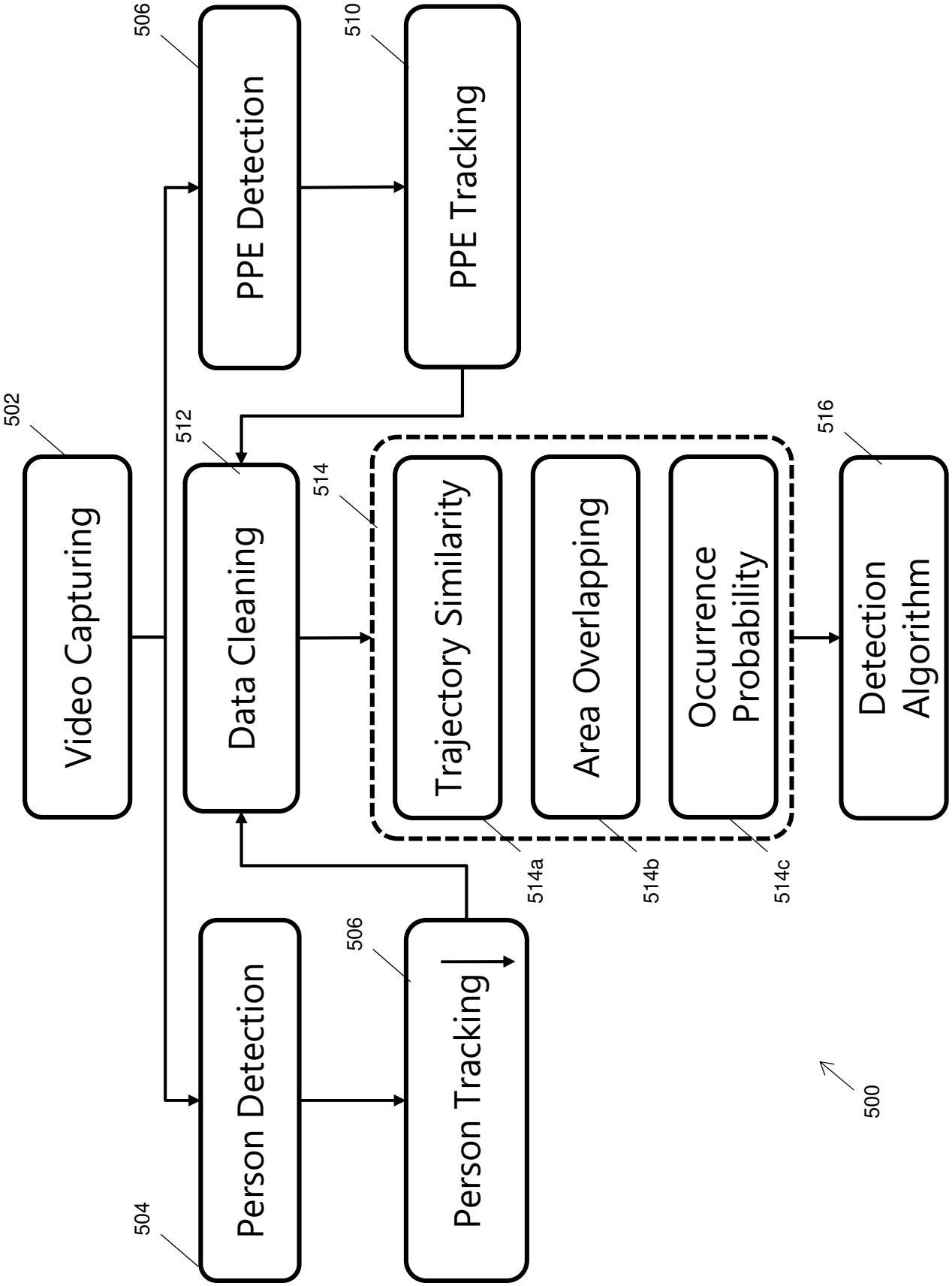

Video Capturing
502
Data Cleaning
512
PPE Detection
506
PPE Tracking
510
Person Detection
504
Person Tracking
506
514
Trajectory Similarity
514a
Area Overlapping
514b
Occurrence Probability
514c
Detection Algorithm
516
500

Figure 5

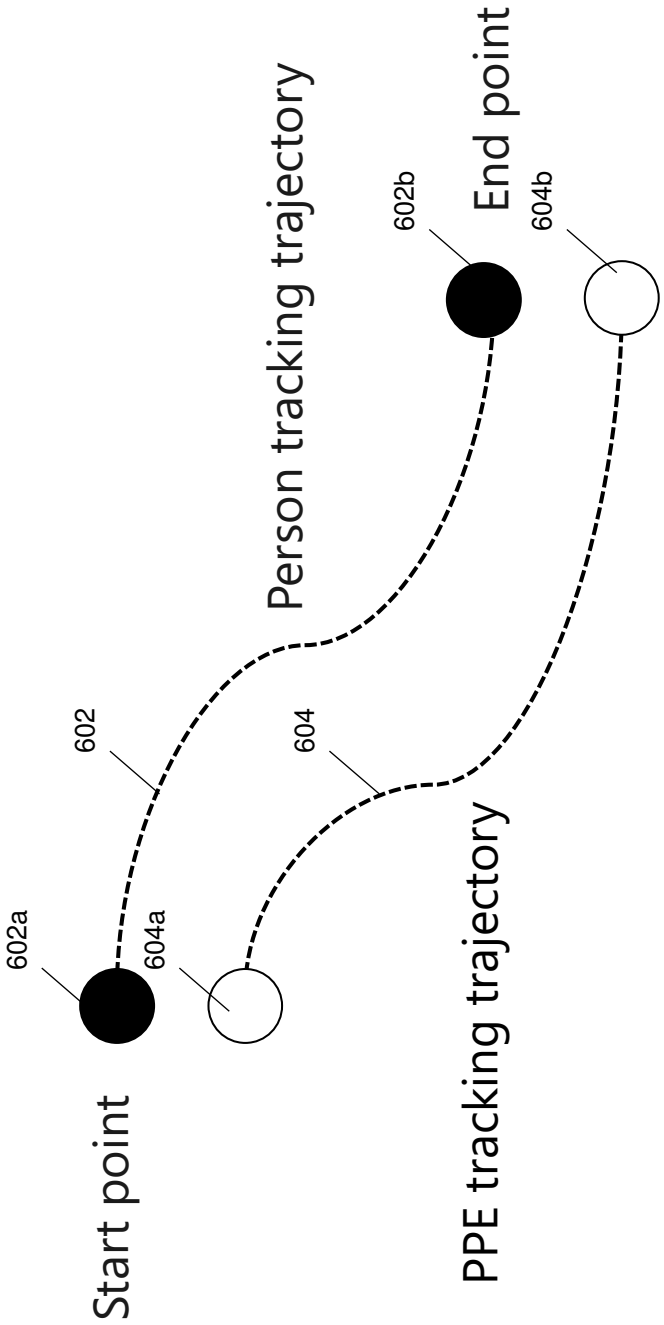

Start point
PPE tracking trajectory
Person tracking trajectory
End point
602a
604a
602
604
602b
604b
600

Figure 6

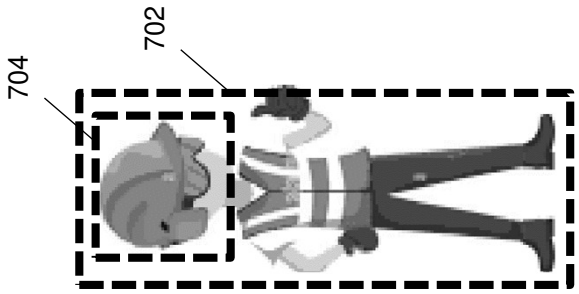


Figure 7

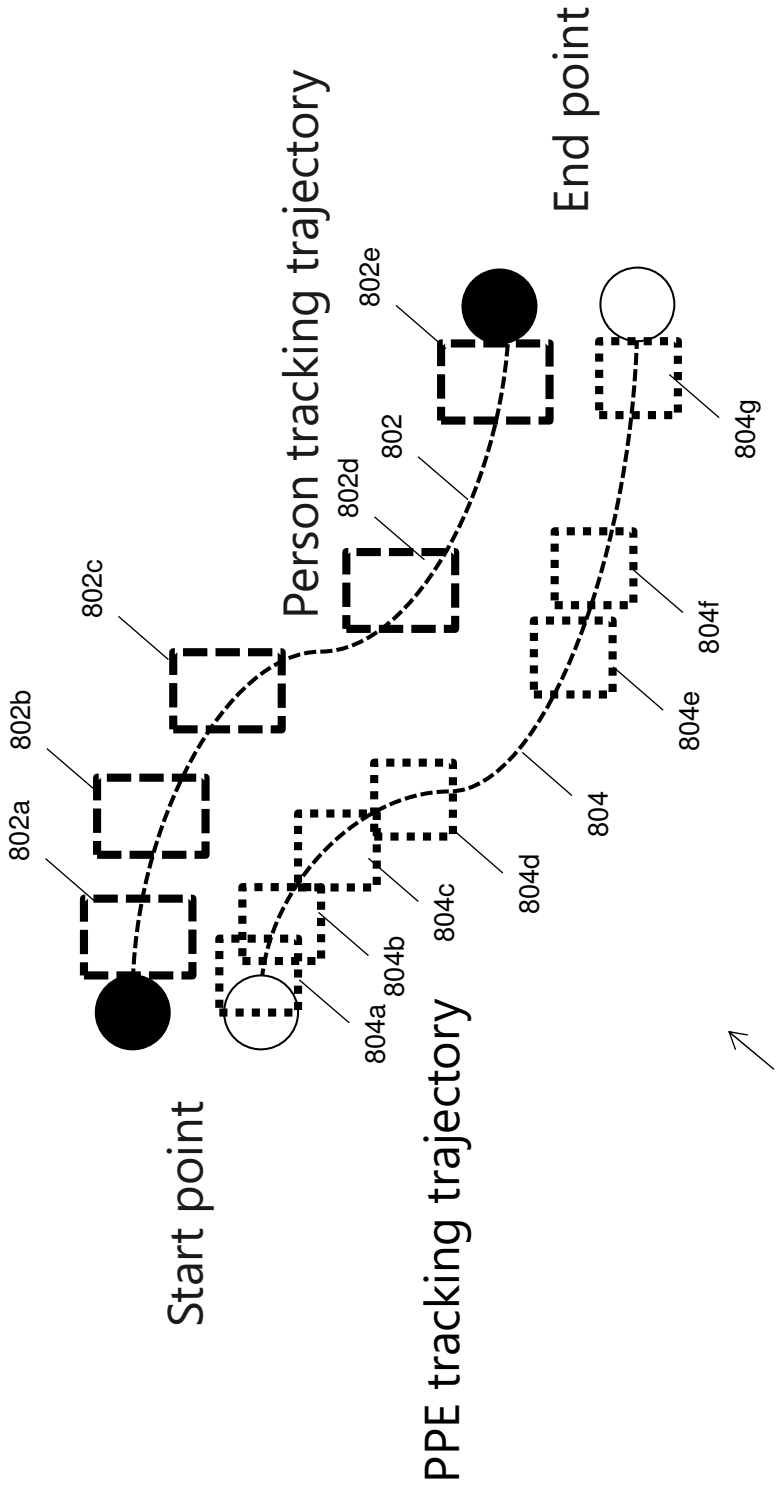

Start point
PPE tracking trajectory
Person tracking trajectory
End point
802a
802b
802c
802d
802e
802
804a
804b
804c
804d
804
804e
804f
804g
800

Figure 8

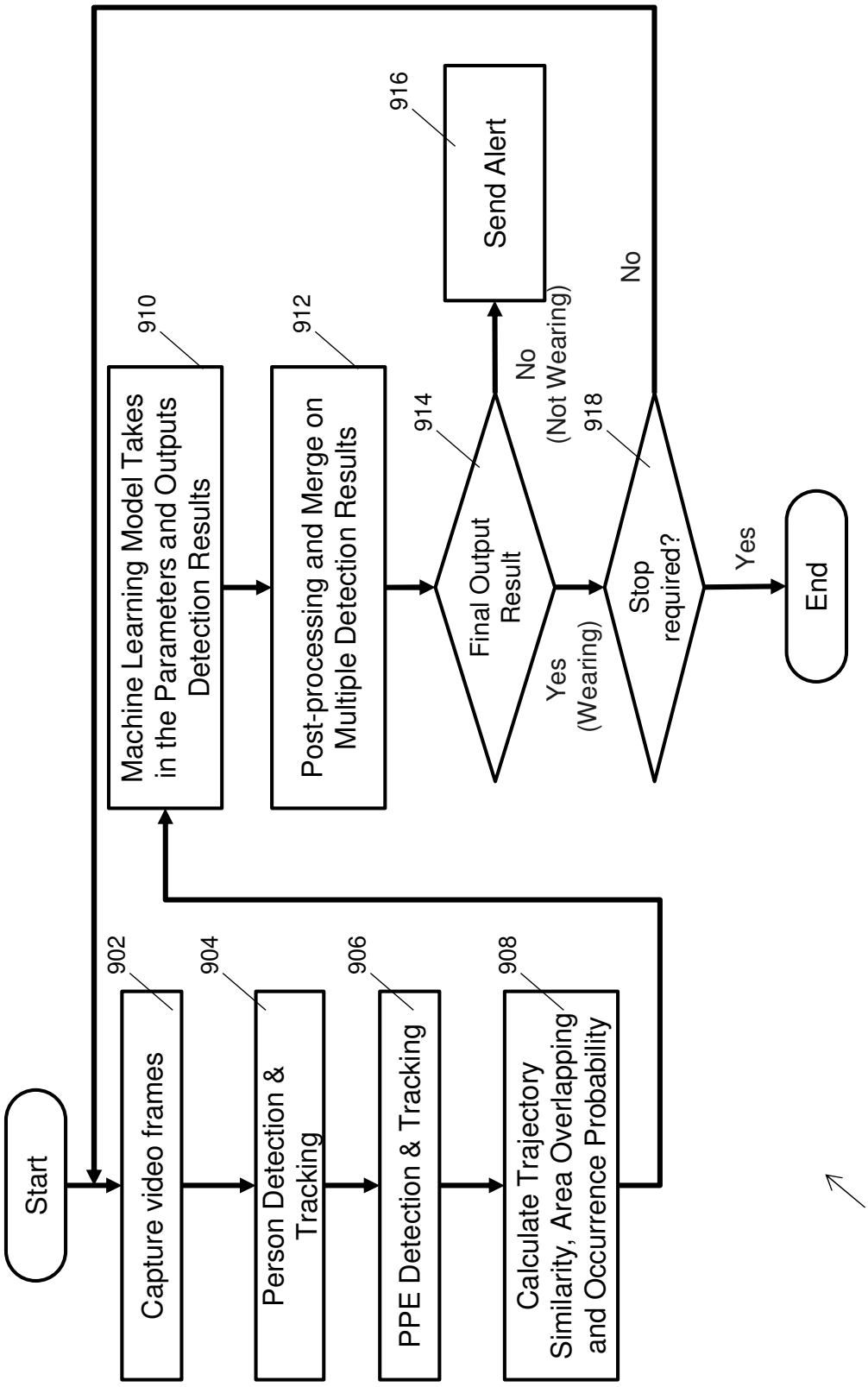

Start
Capture video frames
902
Person Detection & Tracking
904
PPE Detection & Tracking
906
Calculate Trajectory Similarity, Area Overlapping and Occurrence Probability
908
Machine Learning Model Takes in the Parameters and Outputs Detection Results
910
Post-processing and Merge on Multiple Detection Results
912
Final Output Result
914
No (Not Wearing)
Send Alert
916
Yes (Wearing)
Stop required?
918
No
Yes
End
900

Figure 9

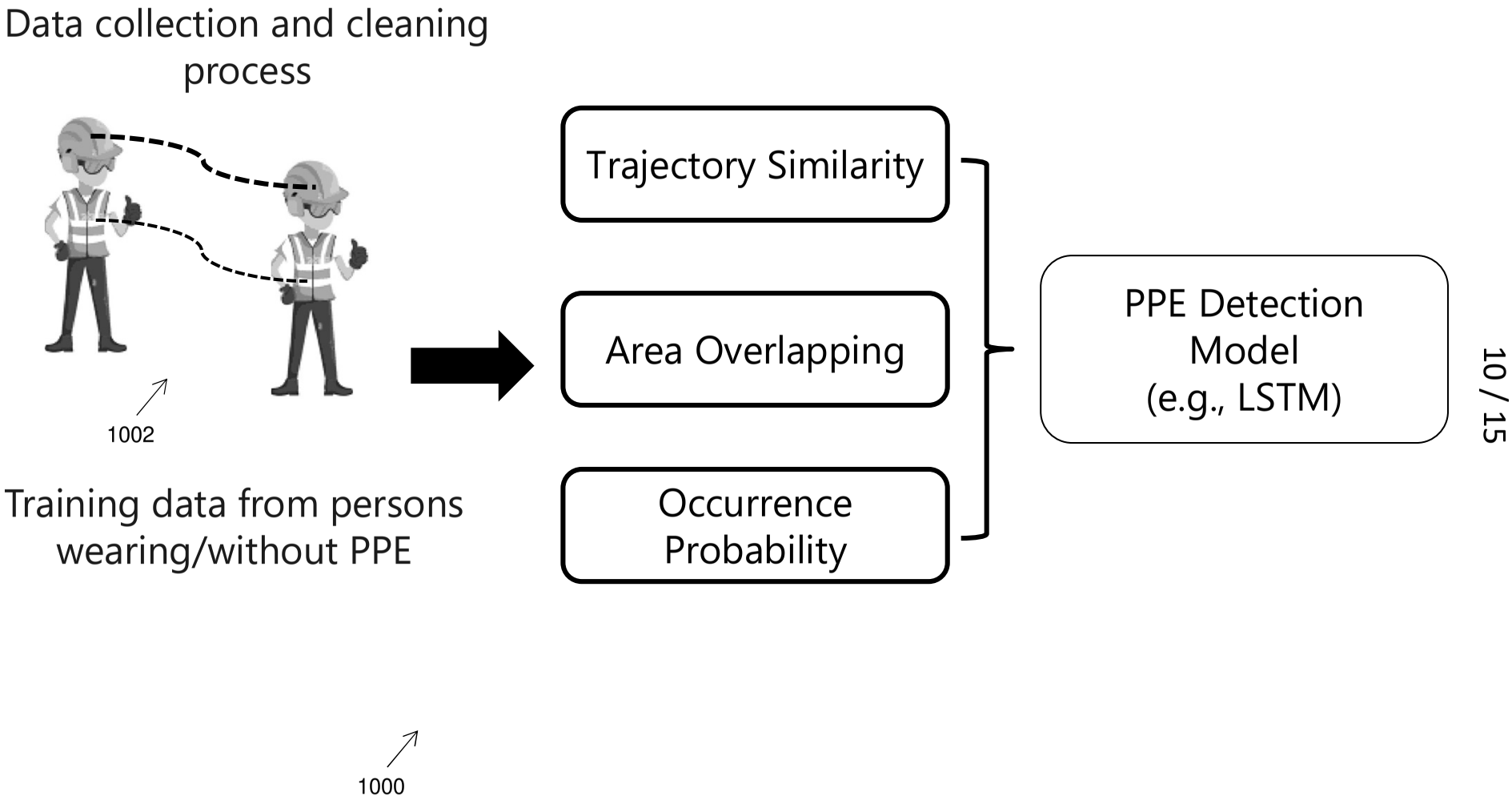

Data collection and cleaning process
1002
Training data from persons wearing/without PPE
Trajectory Similarity
Area Overlapping
Occurrence Probability
PPE Detection Model (e.g., LSTM)
1000

Figure 10

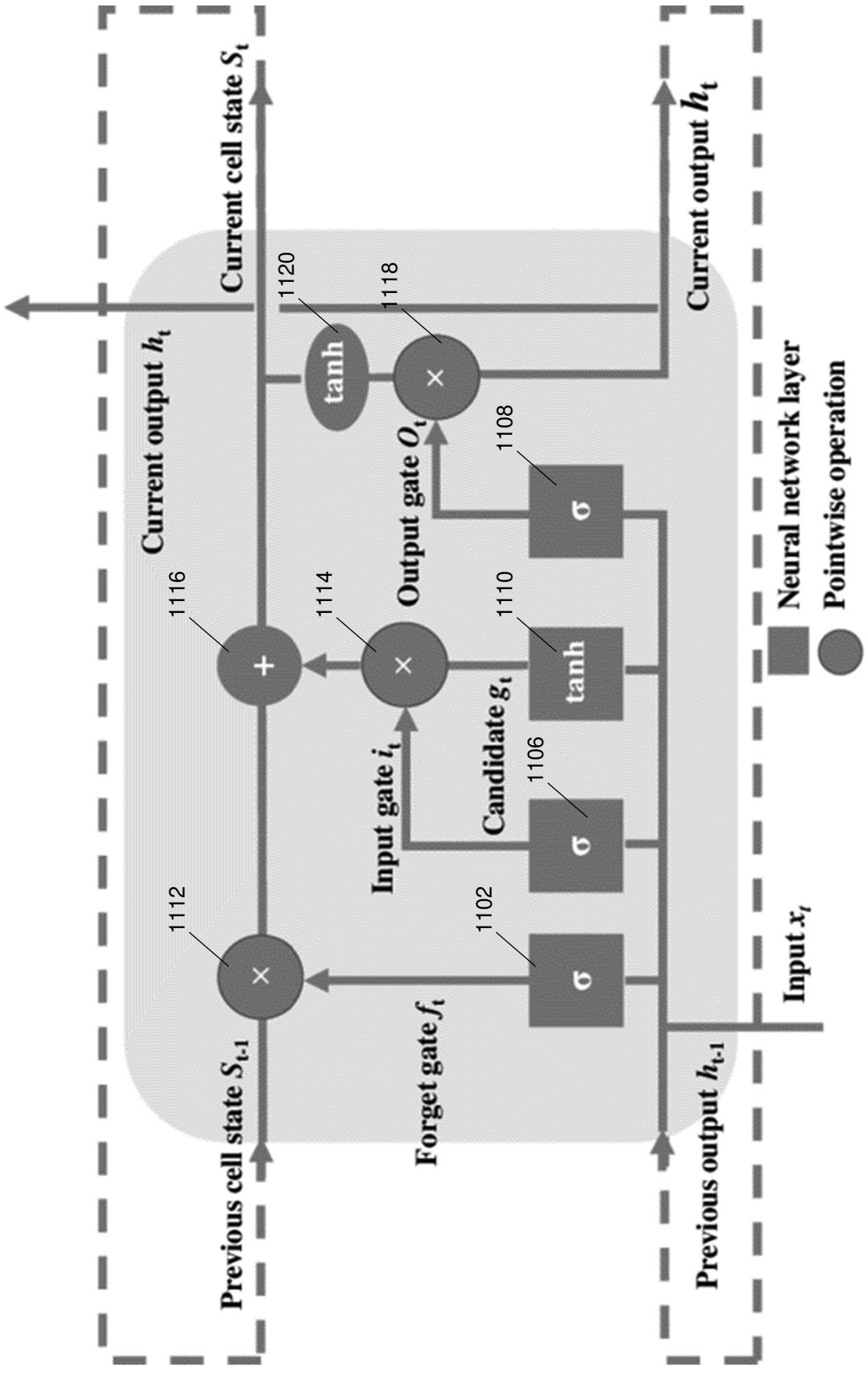

Previous cell state S_{t-1}
Current cell state S_t
Previous output h_{t-1}
Current output h_t
Input x_t
Forget gate f_t
Input gate i_t
Candidate g_t
Output gate O_t
1102
1106
1108
1110
1112
1114
1116
1118
1120
σ
tanh
×
+
Neural network layer
Pointwise operation
1100

Figure 11

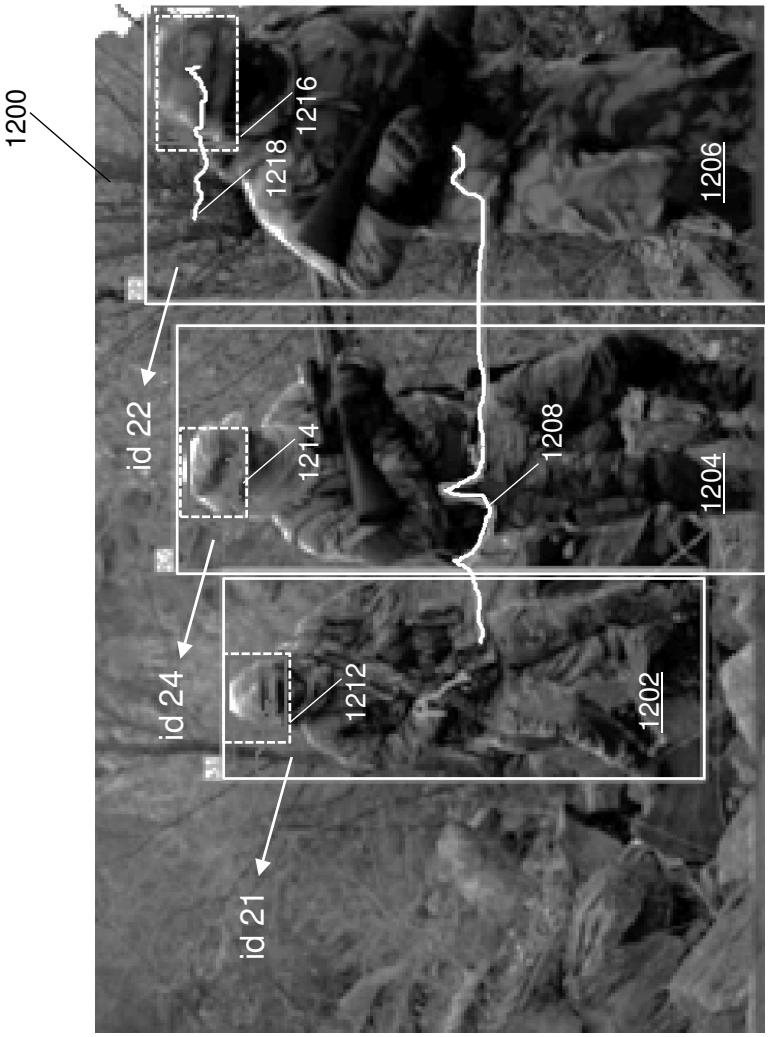


Figure 12


1300
id 1
id 2
id 4
1302
1304
1306
1314
1316
1322
1324
1326
1334
1336

Figure 13

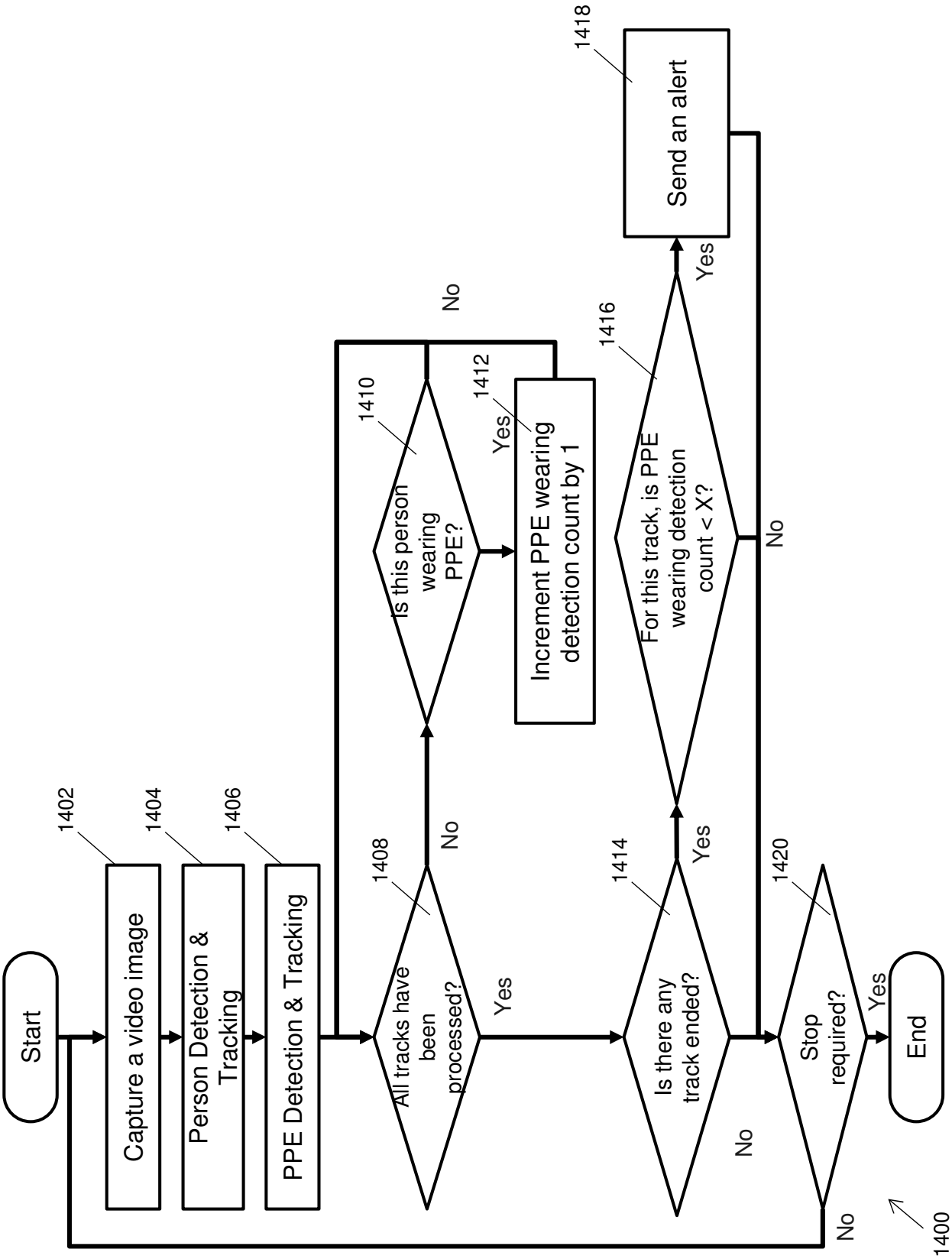

Start
Capture a video image
Person Detection & Tracking
PPE Detection & Tracking
All tracks have been processed?
Is this person wearing PPE?
Increment PPE wearing detection count by 1
For this track, is PPE wearing detection count < X?
Send an alert
Is there any track ended?
Stop required?
End
1402
1404
1406
1408
1410
1412
1414
1416
1418
1420
1400
Yes
No

Figure 14

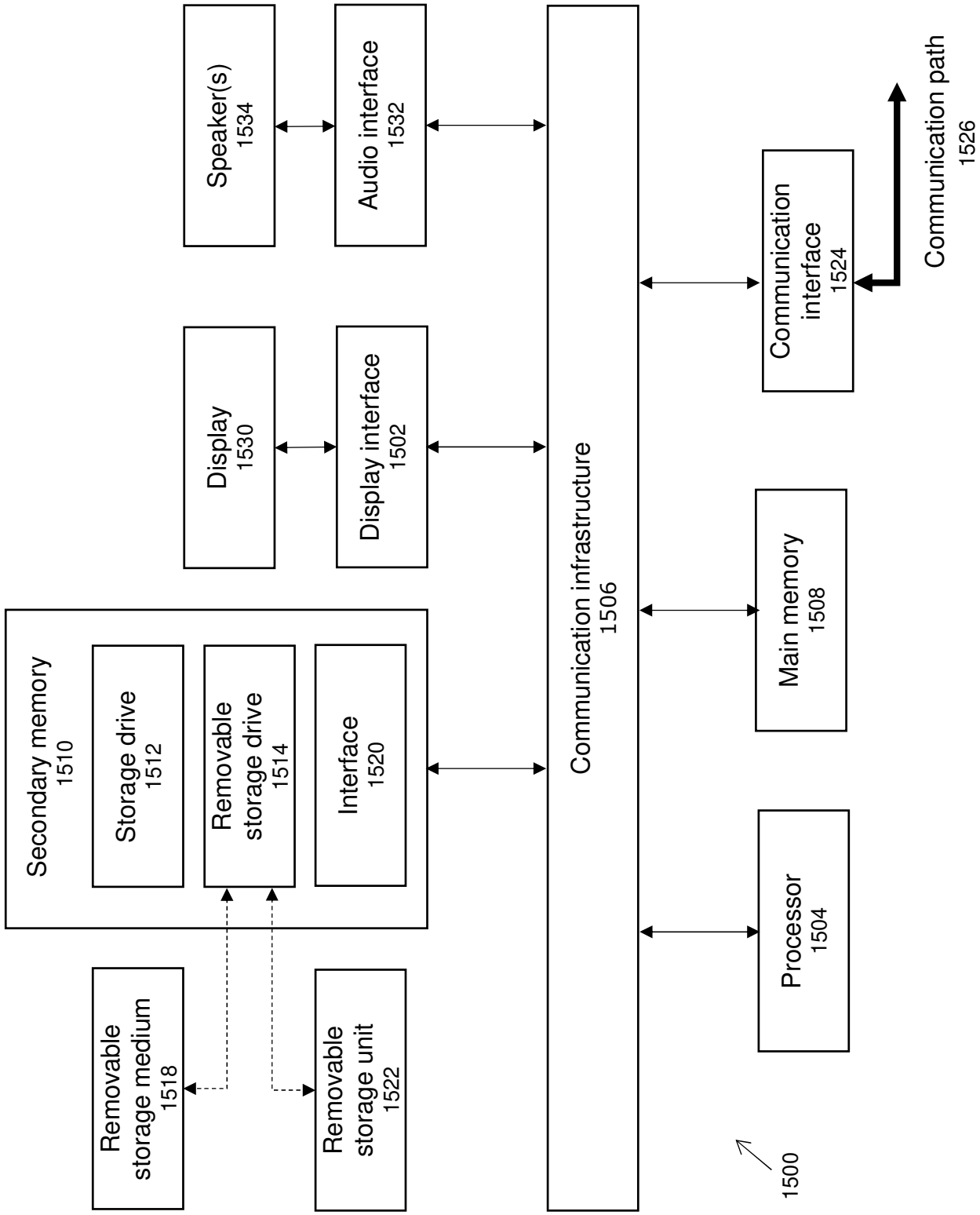

Speaker(s)
1534
Audio interface
1532
Display
1530
Display interface
1502
Secondary memory
1510
Storage drive
1512
Removable storage drive
1514
Interface
1520
Communication infrastructure
1506
Communication interface
1524
Communication path
1526
Main memory
1508
Removable storage medium
1518
Removable storage unit
1522
Processor
1504
1500

Figure 15