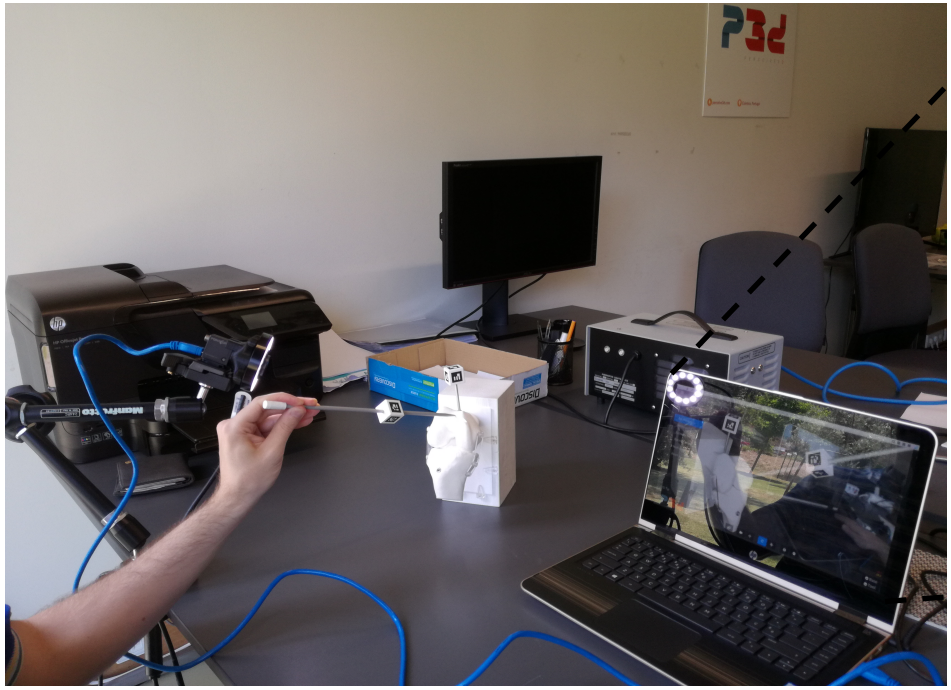
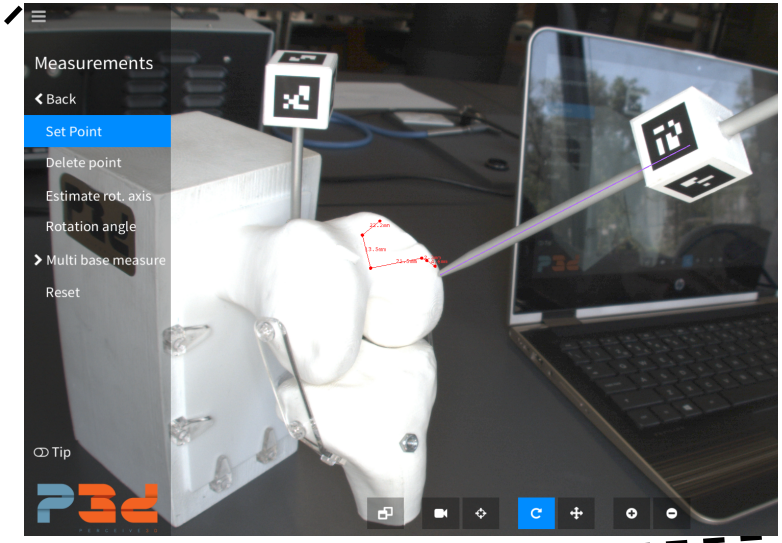
# Report – Marker Illumination Conditions & Visual Tracking Vs Optotrak

16-06-2017

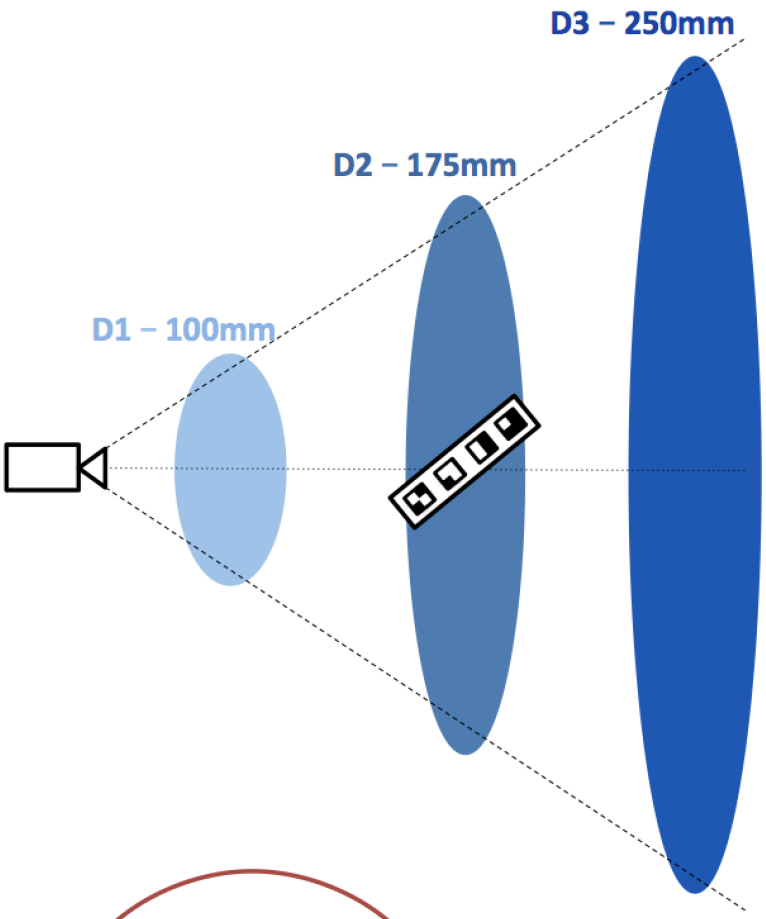




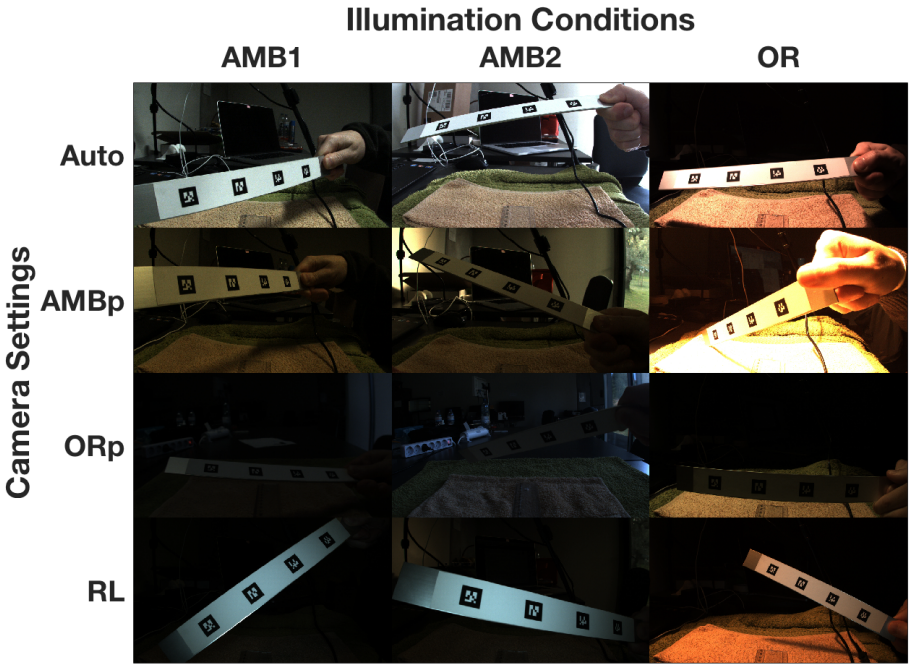

Innav / Visual Tracking

Optotrak Certus

Two tracking systems under analysis:
Visual Tracking &
Optotrak Certus




Evaluating accuracy of visual tracking under different light Conditions: Ruler positioned at 100mm, 175 mm and 250mm to the camera. Markers are placed at 50mm, 100mm and 150 from each other.




Pictures from the different light conditions and camera settings

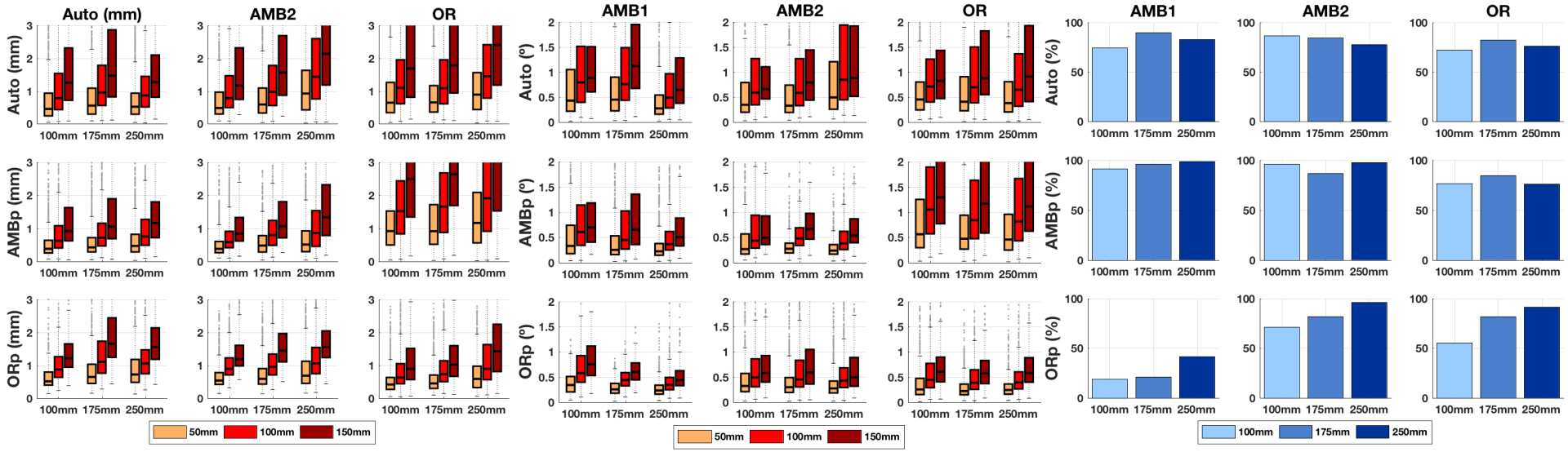
Camera Settings:

- Auto -> automatic setting
- AMBp -> ambient light setting
- ORp -> Operating room setting
- RL -> Ring light Setting

Illumination Conditions:

- AMB1 -> Artificial room lighting
- AMB2 -> Solar room lighting
- OR -> Operating room lighting

Each condition is analyzed for the different measures combinations from the scheme.

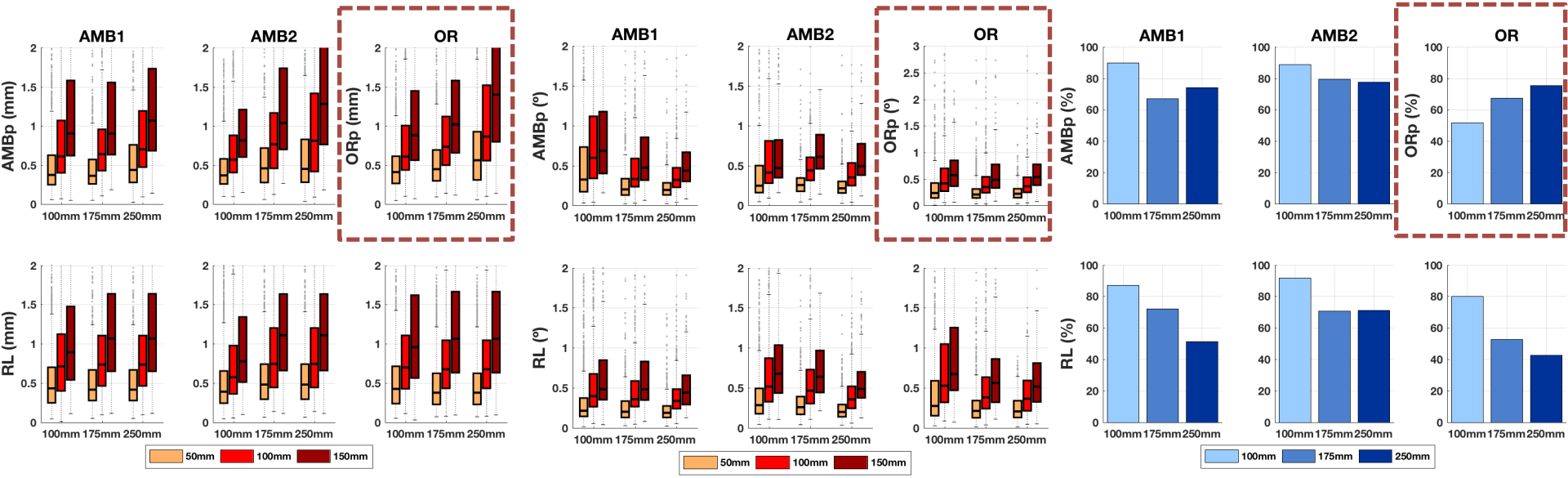



## Translation Errors

1. Mudar para erro relativo juntando todas as distâncias entre marcadores
2. O comportamento entre AMBp e OR para AMB1 e AMB2 continua a ser muito semelhante (é estranho)
3. A detecção de ORp para AMB1 é estupidamente baixa e para AMB2 já é boa????
4. Os rácios para detecção em AMBp e ORp não são consistentes com o que está em baixo (o que raios se passa)?

- Errors were calculated for the combinations named in labels with a marker moving ruler, we start to analyze the first studied camera settings, Auto, AMBp and ORp;
- In the above figures are plotted errors from the difference of vector norm of translation and rotation with the true ground truth vectors;
- Automatic camera setting (Auto) shows increased errors;
- Ambient camera setting (AMBp) is strong with ambient light conditions (AMB1 and AMB2) but awful in operating room light condition (OR);
- Operating room camera setting condition (ORp) is accurate with Operating room light condition (OR) but worse in ambient light conditions. Also, in this camera setting detection rates tend to be lower.

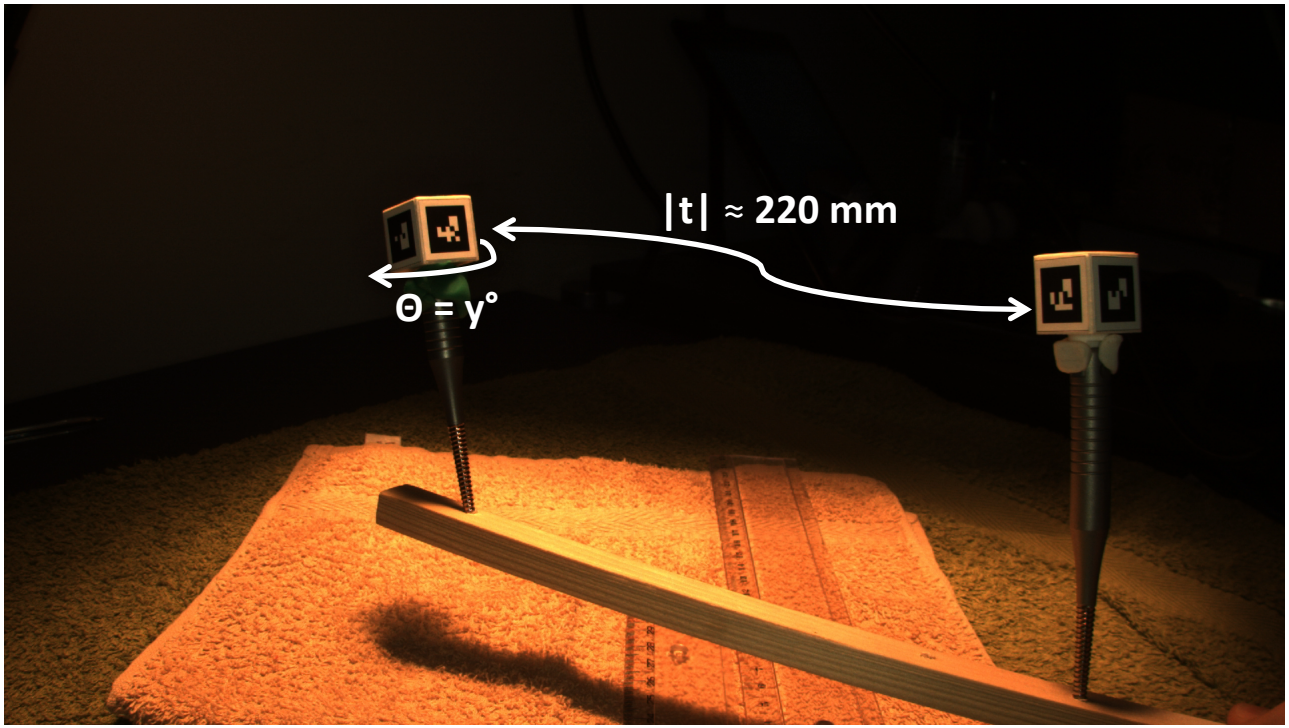
➢ None of the camera settings is completely accurate and suitable across the light conditions



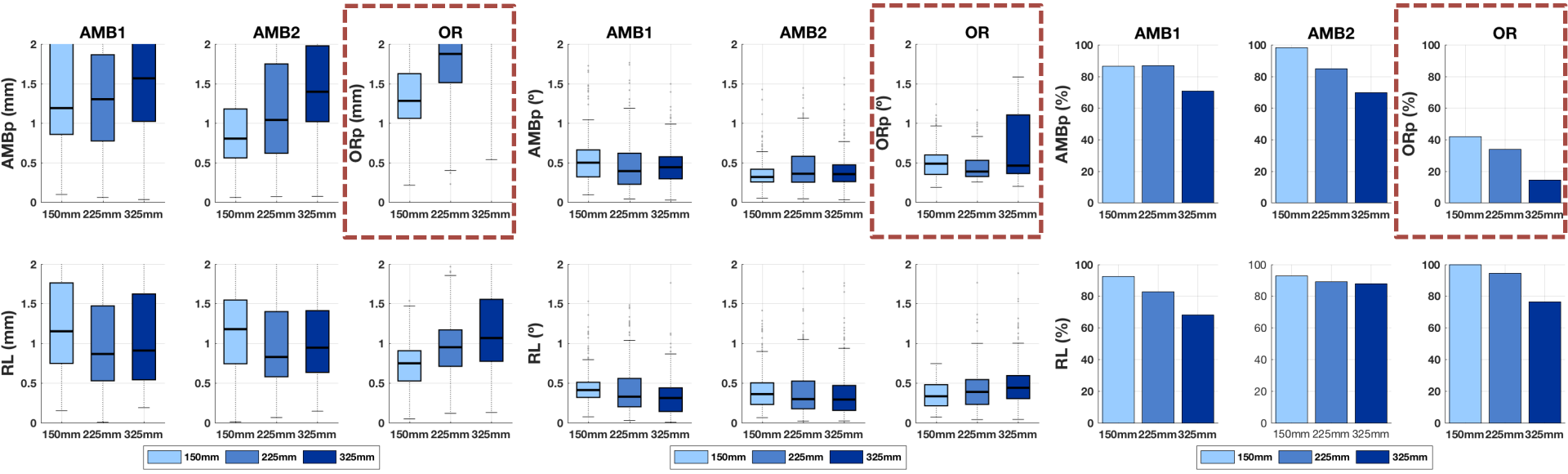

Translation Errors Rotation Errors Detection Rates

- To uniformize errors across all light conditions, a new camera setting is developed: the Ring light (RL) camera setting;
- The new RL camera setting is compared with the best approaches from before (AMBp -> AMB1 and AMB2 & ORp -> OR, surrounded by a dashed red box in the figures);
- Results suggest uniformization of errors across all light conditions with overall slightly improvements in accuracy;
- Detection rates are not impressive for larger distances to the camera (due to changes in the new image processing pipeline);
- In certain cases, nearest distances to the camera reveal high errors, supposing overexposure of markers.

➢ Ring Light stabilizes light condition influence but detection rates decrease




- Cube approach composed by planar markers at each face to improve detection rates.

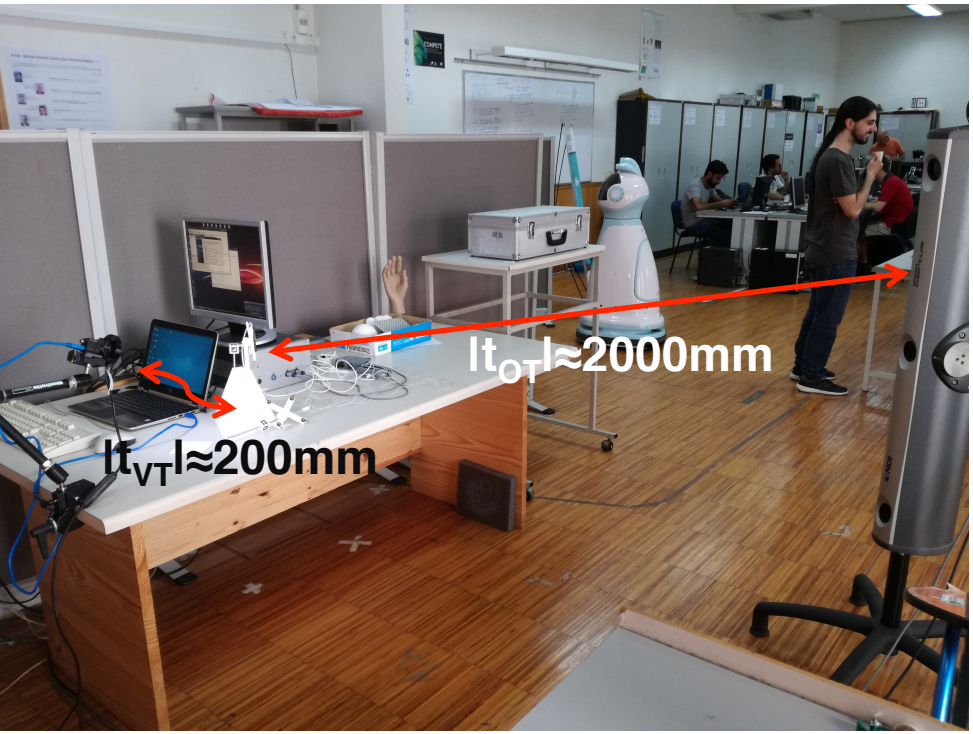



Translation Errors Rotation Errors Detection Rates

1. Mudar translação para erro relativo
2. Porque raio há quebras tão grandes na detecão de AMBp e OR?
3. Os beneficios parecem ser me rotação e detecção

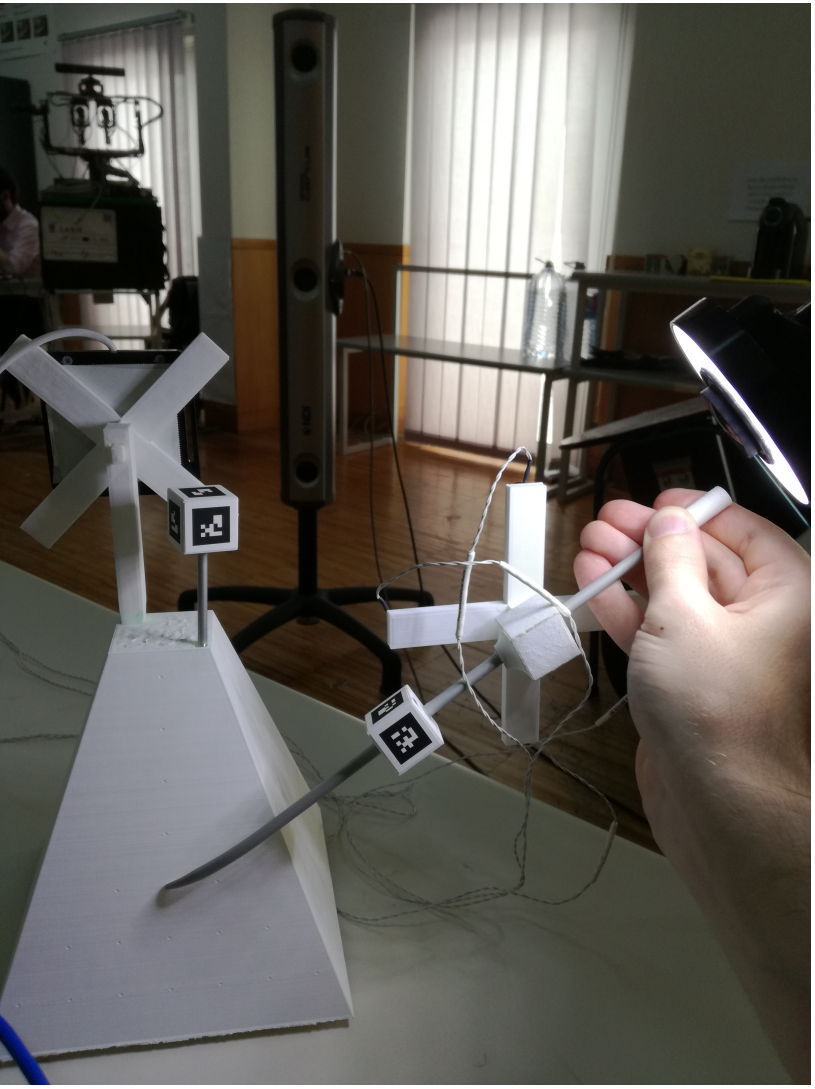
- Errors from the cube new approach;
- Detection rates are higher than before;
- Translation and rotation errors vary around 1mm and 0.5º, respectively, revealing high accuracy.

➢ Cube approach leads to reliable accuracy needed in the OR.




- Working station of Visual tracking (VT) and Optotraking (OT) placed at 200mm and 2000mm, respectively.

- Markers from both tracking systems:
  - VT -> Cubes with planar markers
  - OT -> Active infra-red light markers

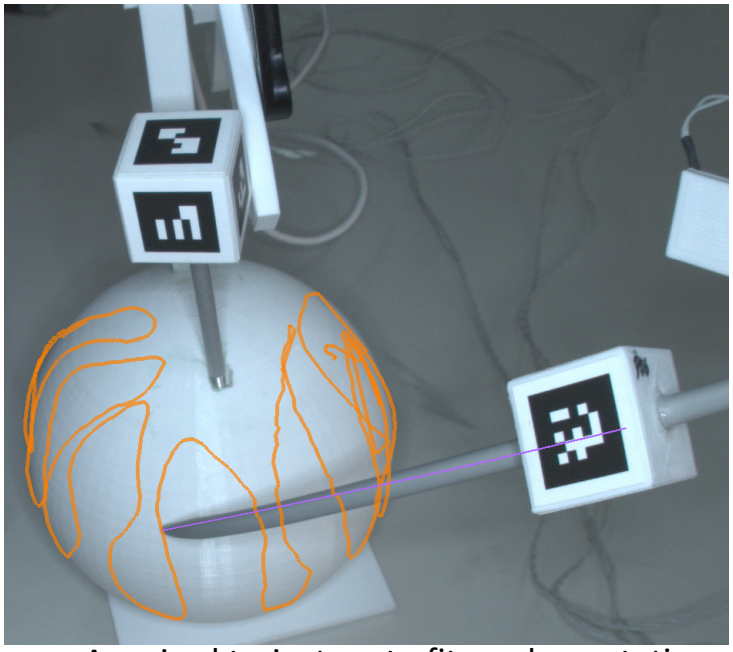


- Accuracy evaluation test for both systems. Well known holes placed in a quadrangular pyramid are registered and the point distance is calculated.

| | Visual Tracking | Optotrak Certus | Optotrak Certus w/Ref |
|---|---|---|---|
| Min | 6.34e-05 | 2.35e-04 | 1.32e-05 |
| Median | 0.4965 | 0.4503 | 0.4773 |
| Mean | 0.5912 | 0.5789 | 0.5858 |
| Std | 0.4529 | 0.4734 | 0.5039 |
| RMS | 0.7447 | 0.7478 | 0.7727 |
| Max | 3.0568 | 2.9125 | 3.8120 |

- Table results from accuracy evaluation.

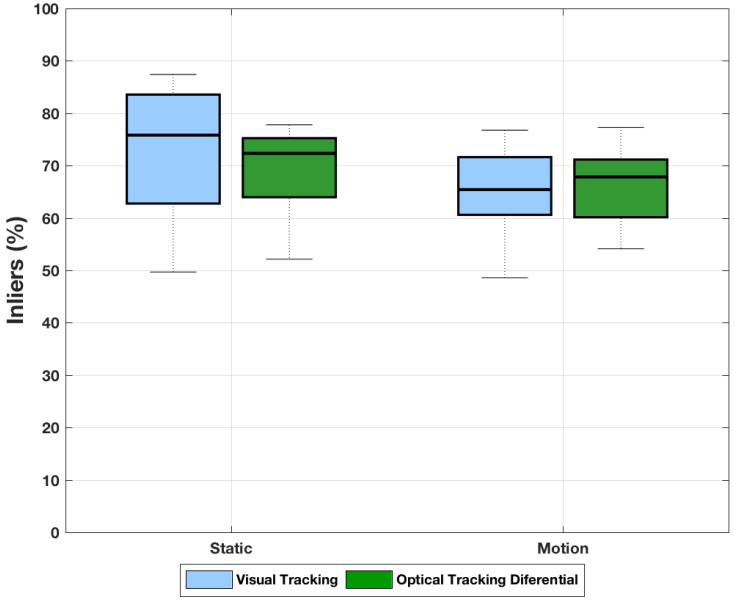
➢ Results suggest accuracy similarities with the gold standard tracking system, the Optotrak Certus.



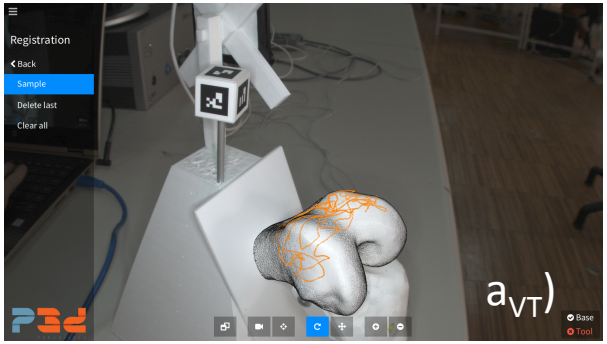
- Acquired trajectory to fit a sphere static or moving position.

- Results suggest a sphere with 50mm or slightly above radius being in accordance with the 3D computer model sphere with the printing plastic dilation (50mm + dilatation);
- Radius are similar for both systems and for static and motion approaches being accordance with the 3D printed model;
- Inliers suggest a lightly decrease in the motion approach for both systems.

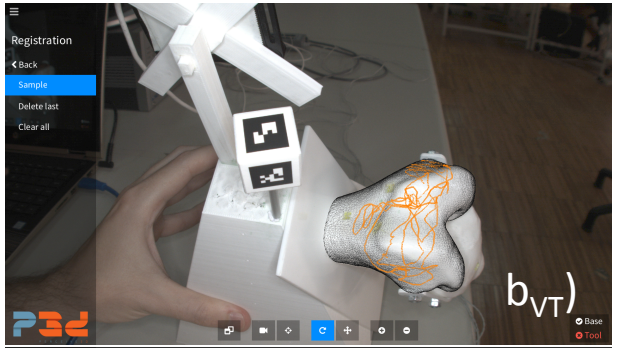

- Sphere fitted radius.



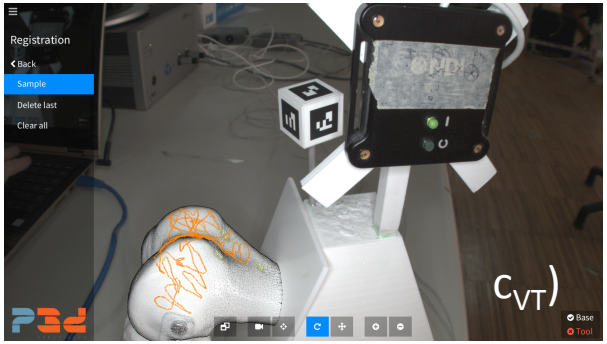

- Percentage of inliers for fitting.



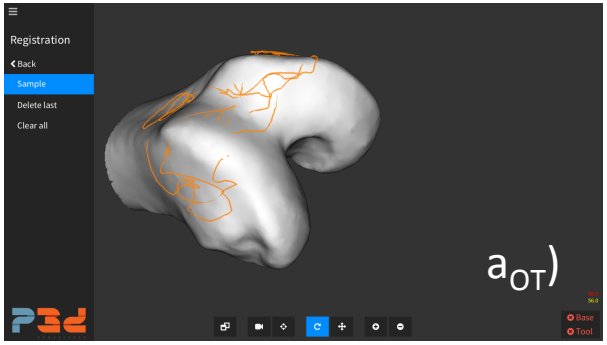
$a_{VT}$)



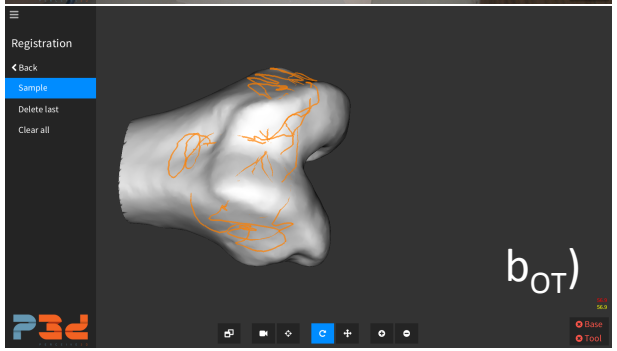
$b_{VT}$)



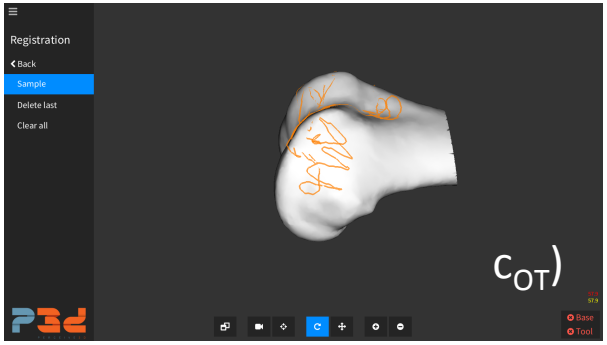
$c_{VT}$)



$a_{OT}$)

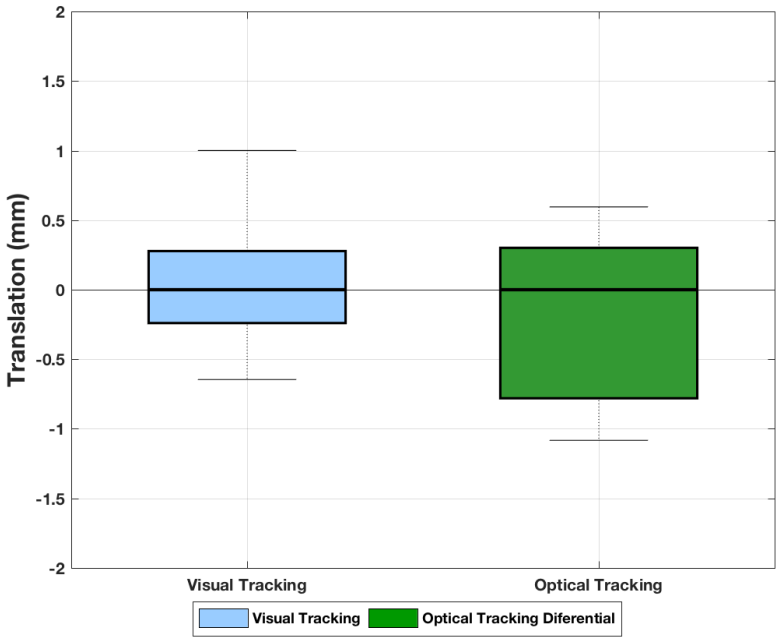


$b_{OT}$)

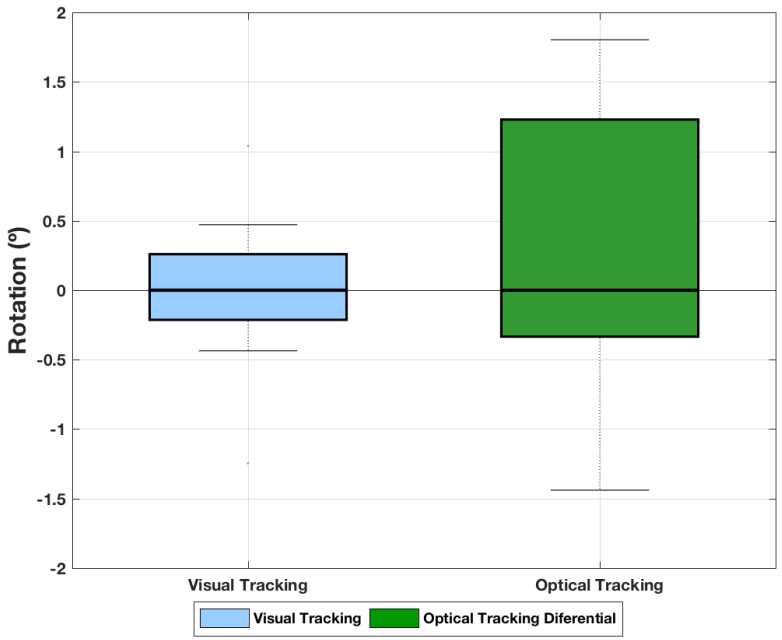


$c_{OT}$)

- Acquired trajectory for knee registration of a printed 3D CT model;
- a) b) and c) shows the acquired trajectory in different angles for VT and OT systems;
- VT analysis shows an AR knee model overlapped in the knee;
- OT analysis shows a VR knee model with the acquired trajectory overlapped.




Translation variation from translation norm vector from the fitted trajectory model compared to the 3D CT model.




Rotation variation from rotation norm vector from the fitted trajectory model compared the 3D CT model.

- Results suggest similarities in translation.
- Rotation norm vector variation from OT seems to have more variability than VT.