Selfie Aligner FAQ

Information and explanations

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This document holds short comments to questions we often get about the Selfie Aligner. This document does not contain confidential information. You are welcome to share it with your colleges but, please, do not publish it on internet or social medias.

Precision:

The Selfie Aligner can align to the mirror tag with a repeatability of less than 0.1 mm and 0.3 mRad. In a test series with 20 alignments the mean deviation was 0.072 mm and 0.214 mRad. Link to test rapport below.
That is 10-50 times better than traditional systems!

The angular alignment accuracy is the crucial point for alignment systems. Traditional systems have an error of 1° (17.5 mRad). At a distance of one meter, from the alignment point, this gives a 17.5 mm error on the position.

The Selfie Aligner can hit well inside 1 mm on a one-meter distance.
See the One-meter Wax Test and the Transistor demo. Video links below.

Light conditions:

Is the system sensitive to light conditions?

No. The Selfie Aligner form an exclusive space, dominated by its own light sources. During the alignment sequence the camera will only be able to see the Mirror Tag and itself.
The illuminated camera tag (around the lens) is located inside the camera housing and have a pitch-black background.
The background for the graphical elements on the Mirror Tag is black to minimize light contamination from surroundings. Spotlights, build into the camera housing, flood the Mirror Tag with white light to over shine other light sources.

Mirror:

Is the mirror in the Mirror Tag sensitive to dust?

No. The mirror is not sensitive to dust or dirt. The selfie image that the camera sees in the mirror does not have to be perfect.
The image can even be out of focus (blurred) without affecting the function.

A mirror with hardened glass will probably be best for safety reasons.
The glass mirror may even be replaced by a polished stainless-steel plate.
The selfie image from this steel plate will be good enough for the aligner.

Camera:

Does the system depend on an expensive high-resolution camera?

No. The Raspberry Pi HQ camera, in the demonstration setup, is only 55 € and it is even too good for the job! An image resolution of 1024x1024 is ok, 1280x1280 is nice and anything higher is overkill. 800x800 will do a fair job, 640x640 is possible but 512x512 is difficult to make stable.

Existing camera:

Can we use the camera we already have on the robot?

Probably yes. Specs for the Selfie Aligner camera is quite low and cameras used on robots for object recognition or inspection will typical be more than good enough for the alignment process.

The camera must, as a minimum, be equipped with a Camera Tag (colored ring around the lens). It will also be nice to have an illumination of the Camera Tag, spotlight for the Mirror Tag and a shielding housing.

Optics:

Will the camera need expensive distortion free optics?

No. Lens distortion is not a problem for the Selfie Aligner. It will work and even give good results on a lens with strong distortion (like a fish eye lens). The method is not depending on high quality images. Images can even be out of focus and still give good results. The 16 mm tele lens for the demonstration setup is only 55€ and it is over qualified for the job.

Calibration of the camera:

Can the camera for the Selfie Aligner be moved or replaced on the robot arm without losing workplace position information from earlier tasks?

Yes. The camera needs to be calibrated to find a tool center point (TCP) for the robot that match the centerline of the camera. If a camera is relocated e.g.: for a part recognition task, the camera must be recalibrated.

Camera calibration and recalibration can be done automatically with a simple program for the Selfie Aligner. Through a series of images this program can calculate enhancement for the camera TCP.
This calibration routine can also be used checking the integrity of the camera installation during normal operation.

After a recalibration the robot will still be able to align to other workplaces and use previous collected information on points of interest. The recalibration only updates the robot controller with new information on how the camera is mounted on the robot arm. Alignment to earlier workplaces and programmed tasks will not be affected by a relocation of the camera. Cameras can also be replaced or changed without losing position information on workplaces. Mobile robots in a fleet may even share information on workplaces.

Program:

Is the program for the Selfie Aligner based on some advanced programming with specialized algorithms or artificial intelligence (AI)?

No. The program for the Selfie Aligner is a very simple demonstration program written in Python. All programming has been done by (non-programmer) Henning Forbech. Mainly as copy-paste from online tutorials. There is plenty of room for improvements to the aligner program but this first simple python program is enough to prove the concept of the Selfie Aligner. At the moment camera and robot arm is not synchronized and the program wait 2 seconds for each image to transfer data and clear buffers. Most of the process time is now spend on waiting.

Computer power:

Does it take a lot of computer power to run the aligner program?

No. The software is running on a Raspberry Pi 4 8Mb (85€) with a Raspberry Pi HQ camera. At 1024x1024 this minicomputer will analyze an image and calculate adjustment for all 6 degrees of freedom in less than 0.5 second.
The analyzing cycle time is strongly related to resolution.
With this short cycle time it will probably be the movements of the robot arm that will that will dominate the time for the alignment. Not the computer time.

Number of iterations in the alignment routine:

How many iterations is necessary to get a good alignment?

Very few iterations, typical 3, is enough to get a good alignment.
From the very first image the Selfie Aligner will have a good recommendation on how to optimize the position of the camera. The next step or steps will only be for optimizing the position to the required precision.
(See also the comments to the demonstration below)

Individual Degrees of Freedom (DoF):

Is the precision of the alignment the same for all DoF?

No. Each degree of freedom can be optimized individually. The six DoF are highly independent and it is possible to optimize the alignment with different precision for each DoF.
This can be used to design the precision of an alignment for a specific task. For a screwing operation it may not make sense to spend time on bringing the robot to a specific angular position in relation to the axis of the screw. This degree of freedom can be left relative open without affecting the screwing process.
The nature of the design in the alignment process allows the user freely to choose the tolerance for each DoF. More sophisticated tolerance rules can be applied. E.g. position tolerance as a sphere or asymmetric ellipsoide.

Extremely high alignment precision:

Is it possible to align with an extremely high precision?

Yes. It is possible to align with a precision that is even higher than the precision of the robot arm!
The encoders in the robot arm have a finite resolution and it will only be possible to place the robot arm in positions separated by a small distance that reflect this encoder resolution. With the robot arm in the closest possible position to the optimal alignment point the Selfie Aligner will still be able to measure the very small final steps that would be needed to get the perfect alignment

This high precision alignment has a practical use when the robot arm is used to find relative distance between points of interest on a workplace. Any errors in this process will later be replicated when the robot come back and use the information from this first setup. To minimize a position error, that will be repeated later, it makes sense to perform this first setup with extra focus on precision.

Safety:

Is the Selfie Aligner controlling the robot?

No. The Selfie Aligner is only producing suggestions on how to move the camera. All movements of the robot arm are done by the robot controller and the robot controller have the full responsibility for these movements.
The Selfie Aligner is passive as e.g., a temperature probe. A robot is not controlled by a temperature probe, nor is it controlled by the Selfie Aligner.

Tag and camera size:

Can the selfie camera and the mirror tag be smaller?

Yes. The Selfie Aligner shown in the papers and used in the videos are the very first version of the system. It was only designed to demonstrate the principle. The next tag will be designed with a ø20 mirror and an overall size of less than 50x50 mm.

Demonstration videos:

Are there videos and more information on the Selfie Aligner?

Yes. You will find more online information on the Selfie Aligner here:
Test reports, business cases, links to videos and news from 4TECH

https://www.toolchanger.eu/selfie-info/

Links to videos here:

Transistor Test:	https://vimeo.com/908762499/798a04ae5b
Quick Wax Test:	https://vimeo.com/853226419/76847cad35
Full Wax Test:	https://vimeo.com/848551417/f03f431220
Proof of Concept auto:	https://vimeo.com/809067285/64ed0cba59
Manuel demo with intro:	https://vimeo.com/759293063/9f1110f0d9

Transistor Wax Intro+wax Proof of concept

More questions on the Selfie Aligner:

We will be happy to help and update you with information on the Selfie Aligner. Call us on: +45 40 38 21 17 or email to: forbech@4tech.dk