Abstract

Despite the fact that most thermography research is still based on 2D imaging techniques, researchers are investigating the true power and calibration of thermal imaging in three dimensions. In our research, multi-camera systems are built up around time-of-flight sensors, used to capture the geometric shape of the test object. The measurement setup and methodology we propose includes an industrial KUKA KR-16W robot which makes it possible to scan the object from multiple viewpoints and adds time as an extra 4th dimension during the passive thermography experiments. This automated system helps to compensate the influence of directional emissivity.

Robot measurement setup

Conclusions

In this research, an automatic calibration procedure for three-dimensional thermal imaging based on a time-of-flight camera and an industrial robot is elaborated. Furthermore, we showed that 3D thermal imaging is possible by combining a ToF sensor with a microbolometer infrared camera. When investigating an object for a certain period of time (4D), we can evaluate the local temperature changes and later compare them to numerical simulations.

Motivation

- From an industrial perspective, it is mandatory to register the local temperatures of a test subject in three dimensions instead of two dimensions to make sure that the temperatures correspond with a real location on the surface of the test sample.
- While line or point scanning techniques need a lot of different and time-consuming scans, time-of-flight imaging is a fast full-field measurement technique.
- Scanning large surfaces and performing automatic calibration benefits from using a robot.
- Validating numerical simulations of heat transfers over time can take some time depending on the test object, for example to investigate the heat propagation of a heat sink. Also if thermal information of different sides of the object is desirable, a multi-camera setup is needed. Both these issues can be overcome by using a robot as a multi-axis manipulator. In this case the robot is continuously measuring the object from different viewpoints using only one infrared camera in combination with a 3D scanning device.
- Thermal imaging is often performed in a conditioned environment and the presence of an operator can be excluded by the use of a robot.
- The accurate movements and known locations of the manipulator simplify the merging of the smart data clouds corresponding with each individual viewpoint.
- Combining 3D, IR and RGB information enables a representation in which the user can recognize each part by its color and shape and see the local temperature of this particular part.

Future work

To improve the quality of the three-dimensional thermal point clouds, a more accurate geometrical scanning technique and a better thermal camera is needed. Therefore, in near future we will combine a projection profilometry system with a cooled infrared camera. A full-field projection profilometry system can easily give 3D points in space with a precision of 0.2mm, which is a huge difference with the 1cm precision that is obtained using time-of-flight imaging sensors.

Fig 1. Close-up of the three-dimensional thermal imaging system.

Fig 2. Picture of the setup containing three cooled balls and one ball on room temperature.

Fig 3. This image shows the measured point cloud including the temperature mapping.