3D Scanning with Proximity Planar Scanner

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Abstract: Result of this work is ready-to-use flexible 3D scanning system providing models of both tiny detailed structures and large object. It can be used in health care to scan parts of body, where brings lot of advantages comparing to present scanning systems. Mechanical constitution, drivers for devices, point-transformation equations and unique calibration procedure have been developed. Then application visualizing measured points and processing them to form of shaded surface have been created.

Introduction

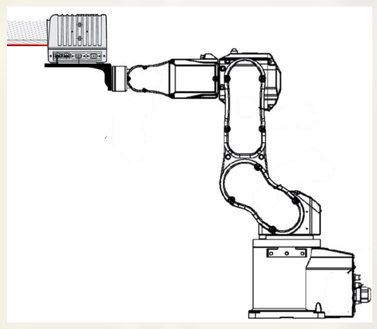
In rehabilitation process after serious injuries or after invasive surgeries, there is necessary to monitor progress of recovery. This is performed by measuring tiny changes of body, what is performed by **comparing present and older 3D model**.

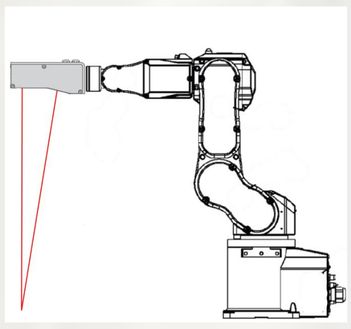
Presently, model building is made by very **uneconomical way**: using Magnetic Resonance Imaging, which contains lot of information about inner structures, which are useless for our purposes – just information about outer surface is extracted. MRI device and its operation **is very expensive**, creating models takes a **long time** and **blocks patients** who need MRI images for more important reason.

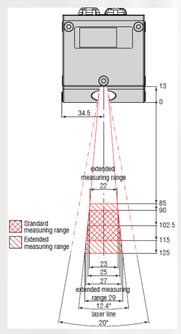
This work brings **many times cheaper** solution with **cheap operation** providing **same results** as MRI. In addition to this, designed 3D scanner is flexible and can scan both **tiny and large structures**, what extends its utilization.

Various Tasks of This Work

1. **Devices Overview and Solution Draft** – what sensors are available, how works and how to reach flexibility => solved by replaceability of scanner

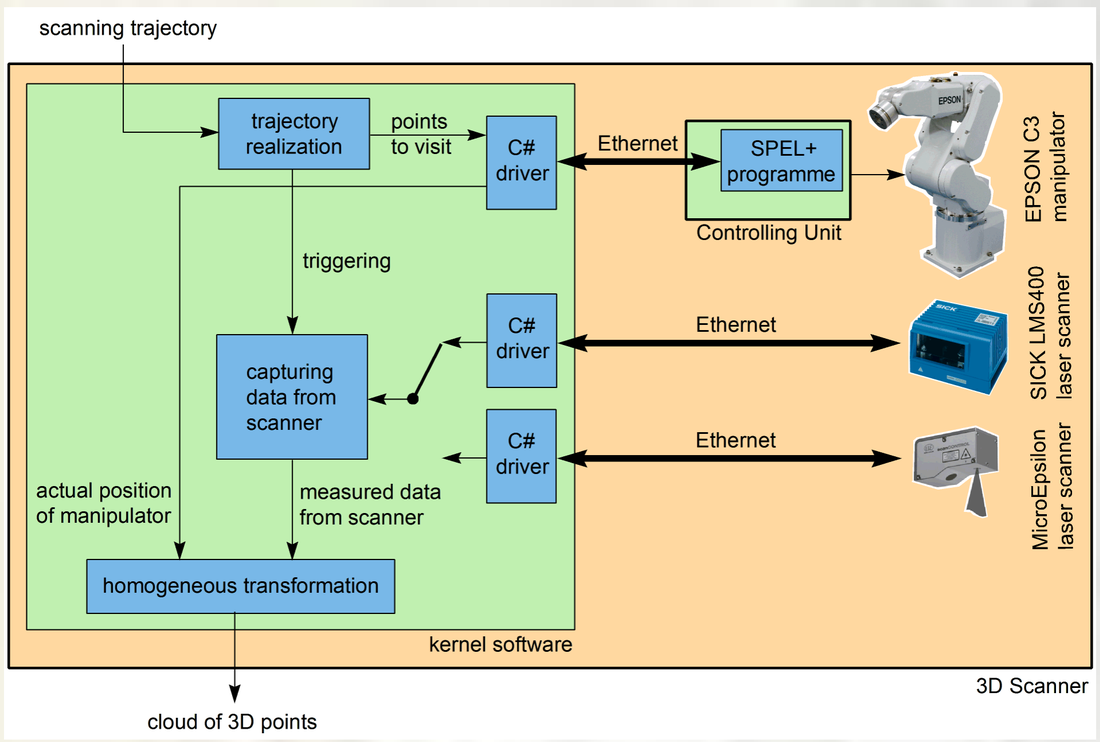






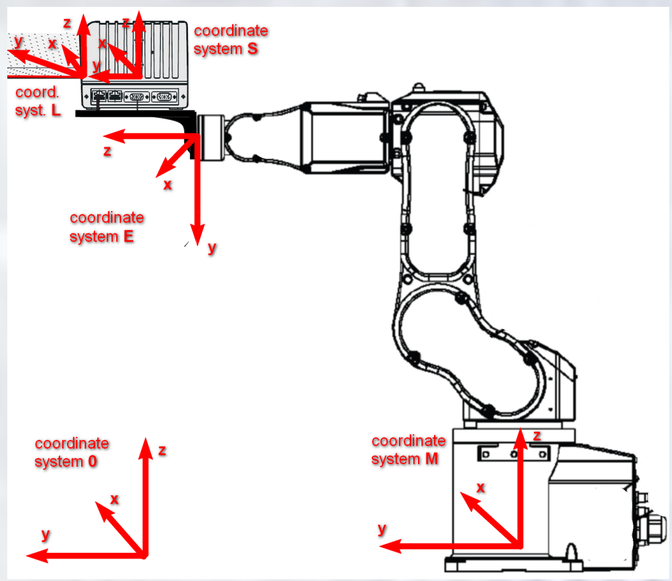
2. **Drivers for Scanners and Manipulator** – programmed in C# using their own protocols, providing uniform interface

3. **3D Scanner Assembly** – mechanical constitution, programming kernel software, developing transformation equations (Homogeneous Transformations)

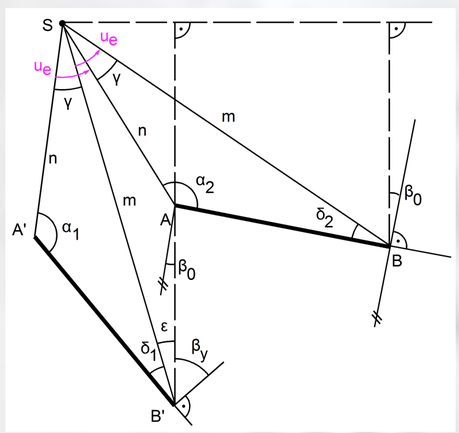


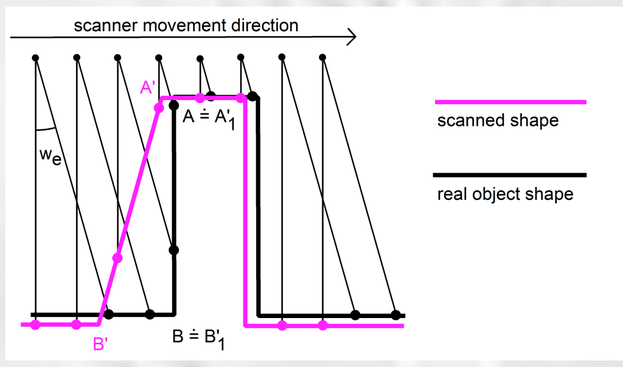
$$H_{0L} = H_{0M} H_{ME} H_{ES} H_{SL}$$

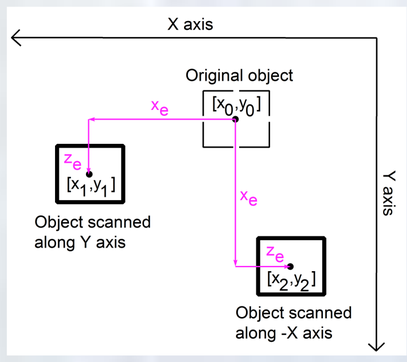
0 ... default coordinate system
M ... manipulator
E ... manipulators' end-point
S ... laser scanner
L ... laser range-finder



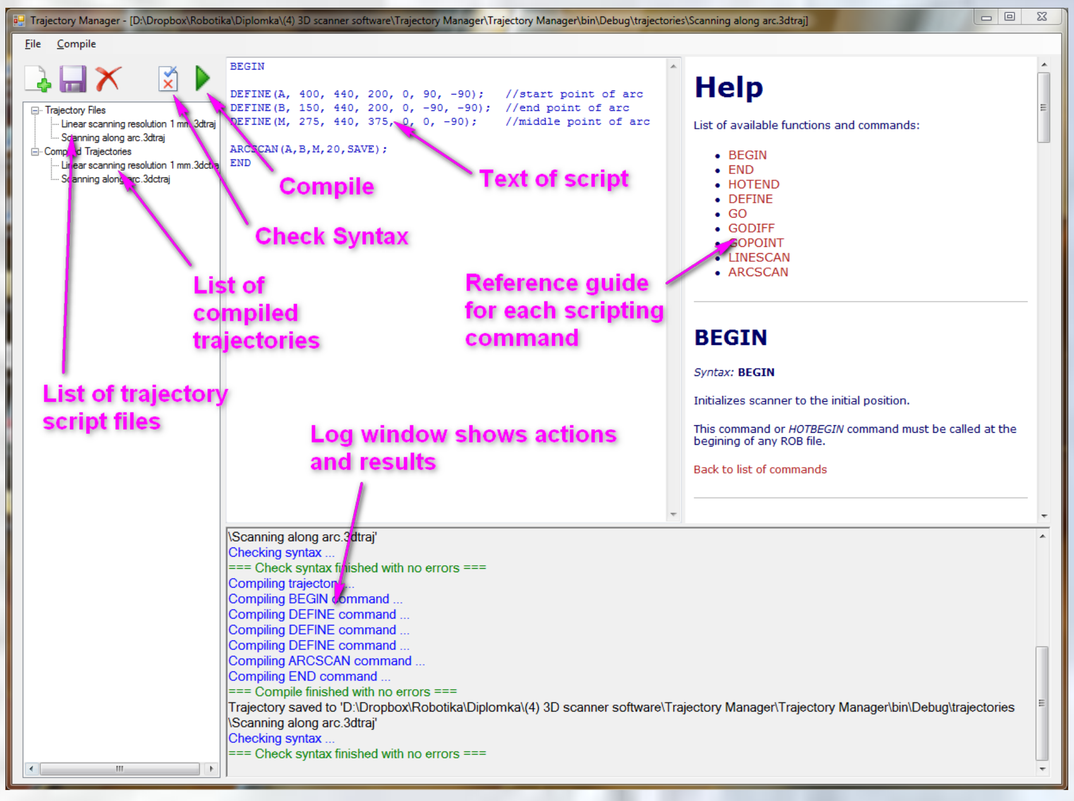
4. **Calibration Procedure** – uncommon solution: using generic calibration object instead of precise one + hybrid computing approach (analytical with simplifications + numeric)







5. **Trajectory Planning Environment** – simple scripting language for trajectory definition => compiled to list of points to be visited



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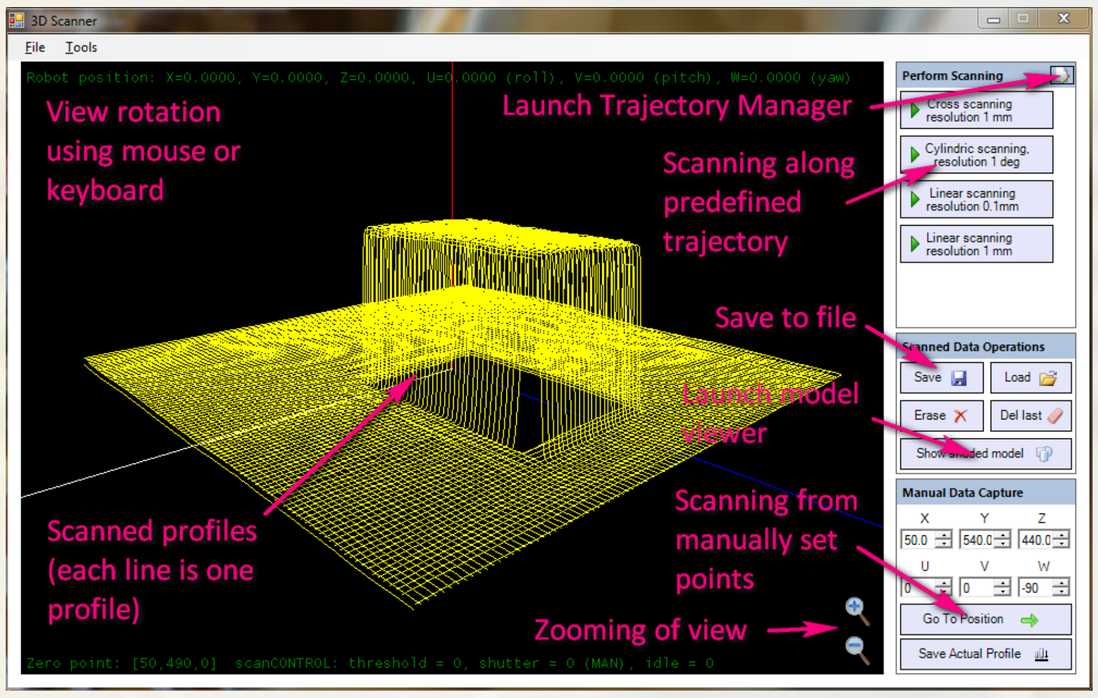
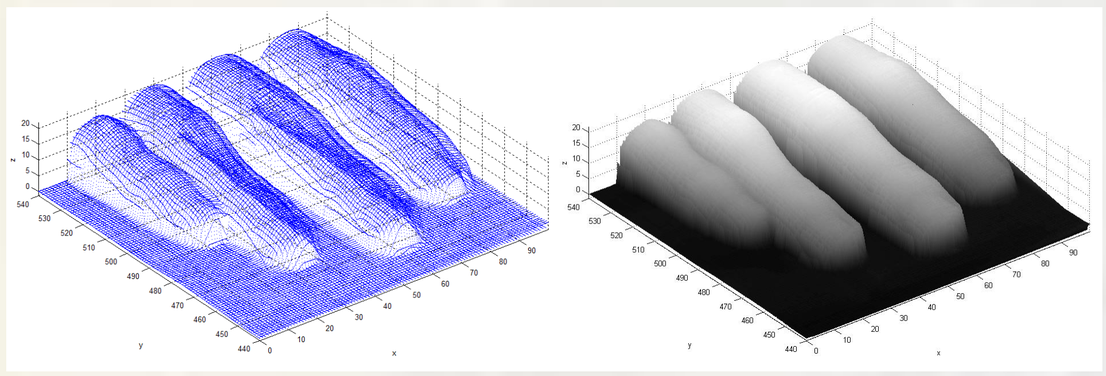
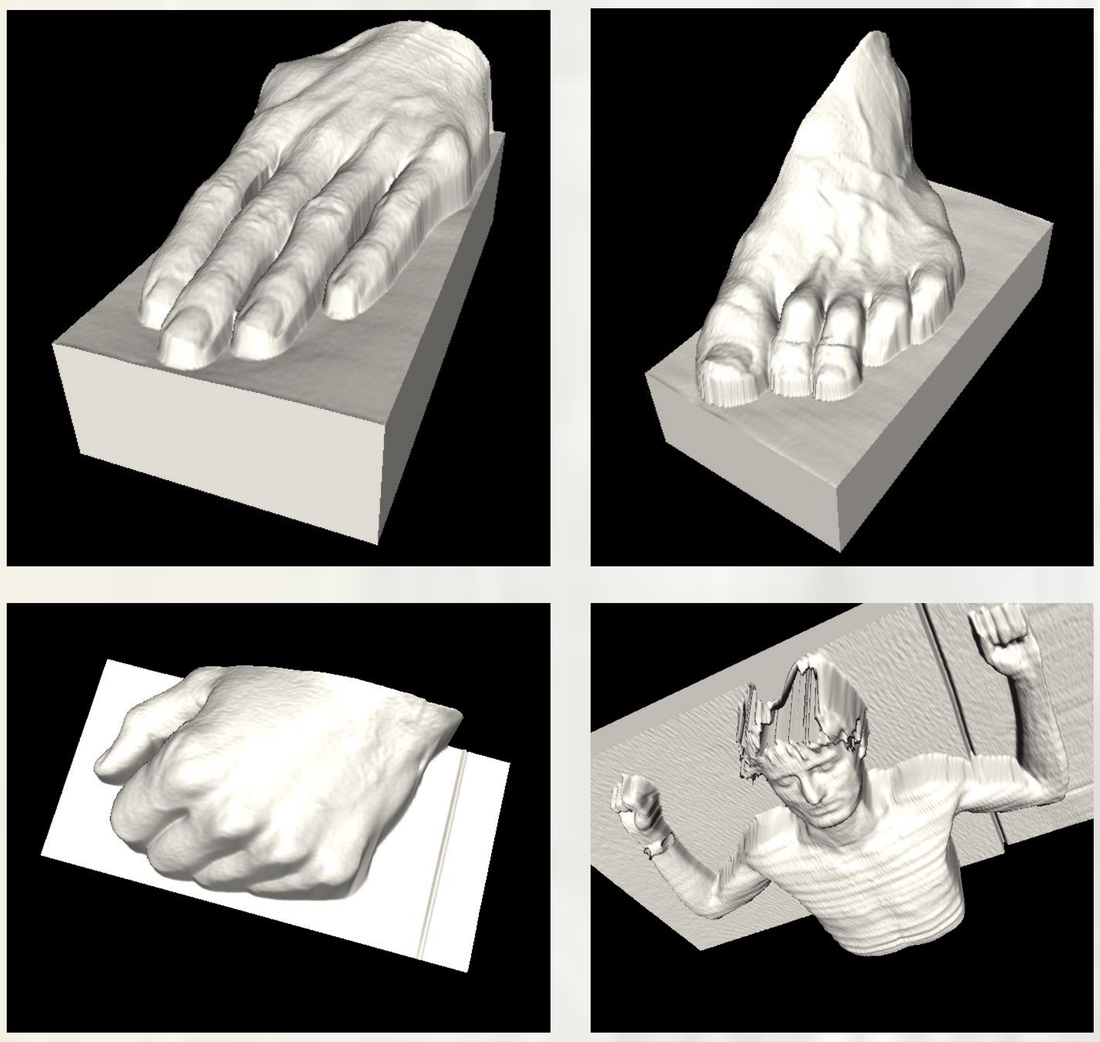
6. **Graphical User Interface** – Uniform GUI for scanner control, scanning using predefined trajectories, saving measurements.



7. **Surface Generation** – generating surface covered models from point clouds using Delaunay Triangulation Method.



8. **Model Visualization Environment** – programming application in XNA framework performing model displaying, rotating and scaling.



First three models were scanned using very accurate laser scanner MicroEpsilon scanCONTROL 2750 based on triangulation principle. Its resolution is up to 40 µm, but measuring range is only 350 – 450 mm => for tiny objects.

Last scan acquired by SICK LMS400 with resolution 1 mm, but with range from 70 cm up to 4 m => for large structures.

Future Extensions

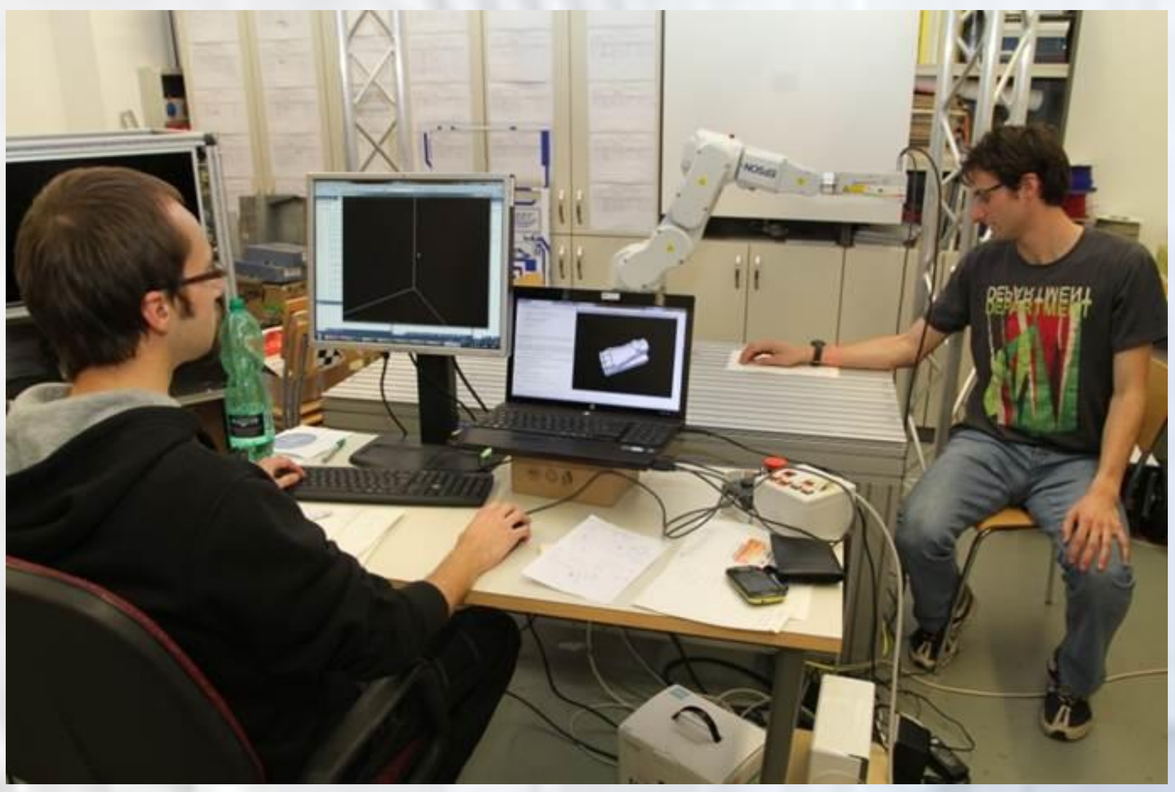
- Extension of trajectory describing scripting language with next functions.
- Implementing more sophisticated surface generation algorithm.
- Covering surface of model with information from CCD camera or thermo vision.
- Extending possibilities of 3D model viewer with measuring functions (volume, length, etc.)

Conclusion

Result of this work is three-dimensional scanner composed from robotic manipulator and laser scanner mounted on its end-point. Solution is universal and not dependent on actually used devices.

Developed device has a wide area of usage. It can be used for scanning complex objects, like a historically valuable objects, which could be preserved by this way for next generations. It can be used also in health care domain for scanning parts of human body in order to be able to compare body status along the time. In this case, it could bring significant savings in acquisition costs and operation costs with keeping quality of service at the same level.

Result of this work is fully-functioning device with controlling software. Final 3D Scanner is just ready to be used.



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