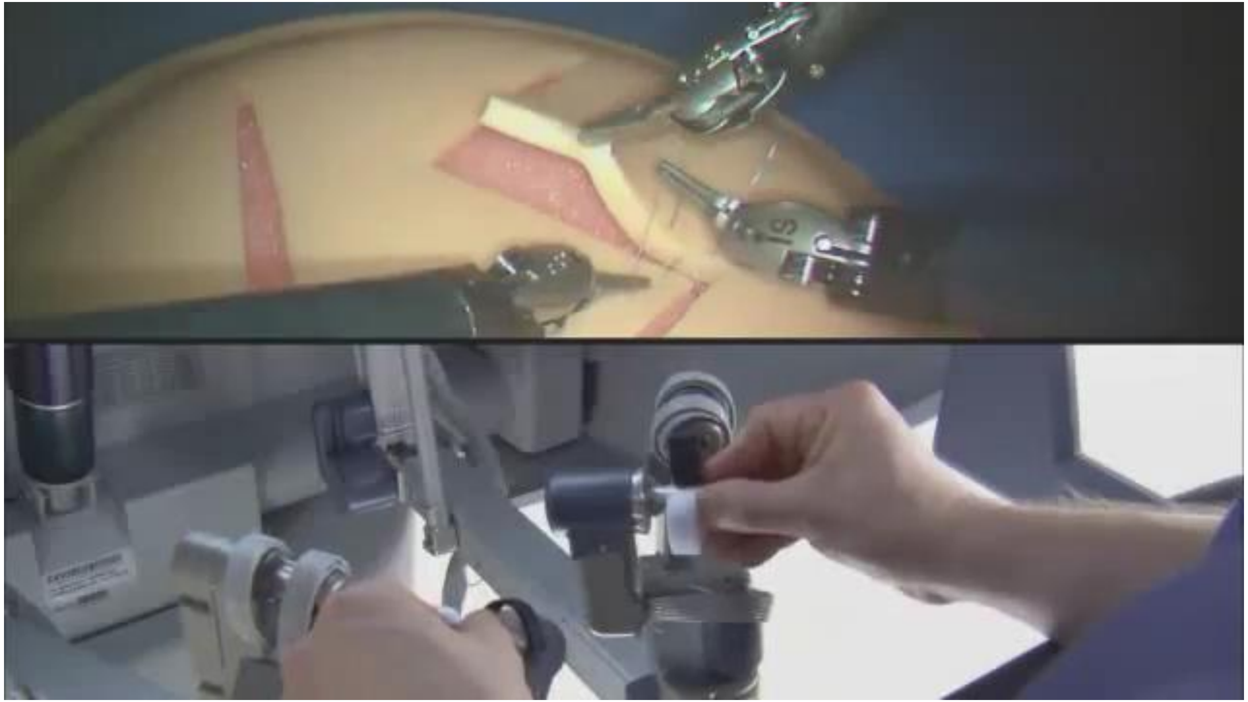
Q & A: Building Humanoids

- **Q1:** In medical robotics, teleoperation is used as well that hopefully does not include many errors. Is teleoperation in medical robotics different compared to DRC?
- **Q2:** Does this depend on the limited bandwidth?

- The decision which level of autonomy to use is task-specific
  - **Example 1:** Disaster Scenario with limited bandwidth → semi-autonomous teleoperation (e.g. using affordance-based grasping and manipulation)
  - **Example 2:** Medical robotics → precise manipulation by human beings may require manual teleoperation in real-time (on lowest control level)

Example: da Vinci Surgery



https://www.youtube.com/watch?v=QksAVT0YMEo

Teleoperation at DRC

"One of DARPA's main goals with the DRC was to advance how robots and their human operators can work in concert to perform difficult tasks."

"We must say we wished we had seem even greater perception and planning autonomy. We felt that there was still too much teleoperation, in part because the […] operators could just manually control the robots and tell them what to do step by step.

[…] In the rubble task, we wanted to see […] the robot scan the terrain, compute a viable path, and then walk over the obstacles—all done autonomously. Instead, we saw the human operators looking at images from the robot's camera and lidar and telling their robots exactly where to place their feet.

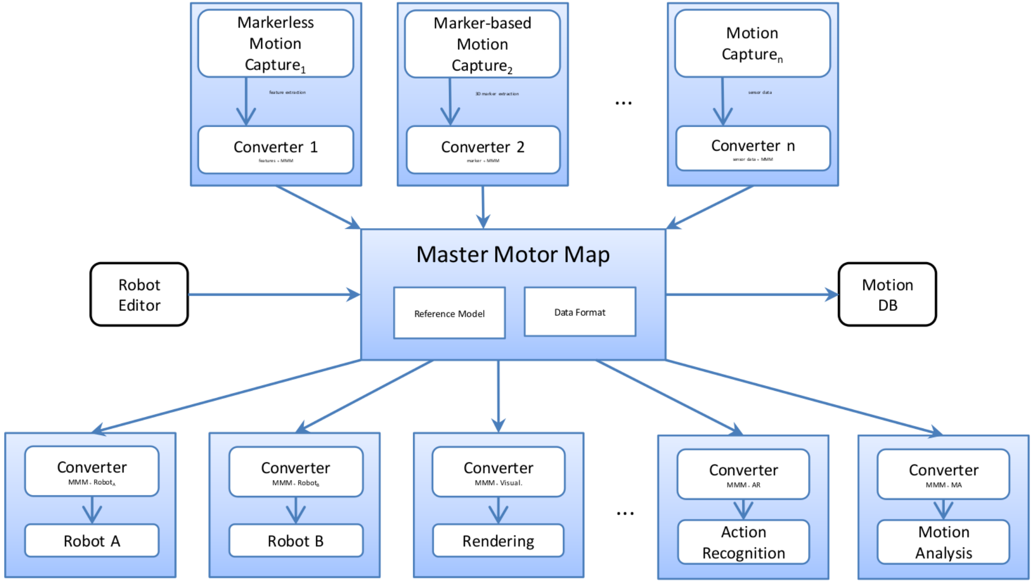
Some may call that a **semi-autonomous** operation, but others may say it's **pure teleop**."

By Evan Ackerman and Erico Guizzo

https://spectrum.ieee.org/automaton/robotics/humanoids/darpa-robotics-challenge-amazing-moments-lessons-learned-whats-next

Q & A: MMM

- **Q3:** Can the human recorded data in MMM directly be used on the robot?
- The recorded data cannot directly be used on a robot → that's why the MMM framework includes converters
- Example:
  1. Marker-based motion capturing (e.g. human actions)
  2. Human-specific parameters are used for conversion into the MMM reference model
  3. Robot-specific converters are used to map the reference model to a real robotic system



Q & A: MMM

Karlsruher Institut für Technologie

- **Q4:** Since the MMM framework is about standardization of data formats – has MMM been used by other research institutions?

- The MMM framework is developed at KIT and used by many researchers around the world as its database includes the largest open-source Whole-Body-Motion dataset
  - Right now, there are ~750 non-KIT users registered to the Database
- More information:
  - MMM Software: https://gitlab.com/mastermotormap
  - MMM Documentation: https://mmm.humanoids.kit.edu/
  - KIT Whole-Body Motion Database: https://motion-database.humanoids.kit.edu/faq/

Q & A: MMM

- **Q5:** Is there data that must be measured for the MMM model and data that is optional (e.g. the hand)?

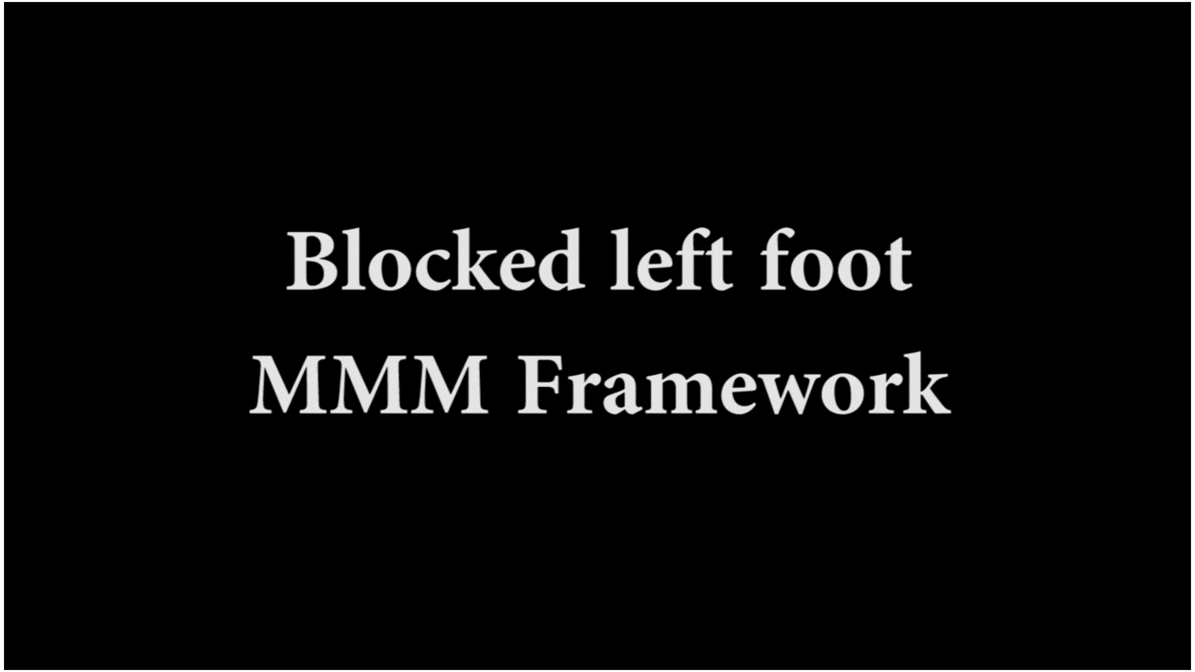
- How much data is required highly depends on the application and robot system
- Trade-off between accuracy <> optimization on target system
- Examples:
  - **Humanoid robots** often have different kinematic structures than humans i.e. robot DoFs < human DoFs → not every single joint is required
  - **Underactuated hands** → ARMAR-6 hands have 14 DoF but only 2 motors
  - **Exoskeletons** → Simulation of prosthesis wearers (see next slide)

→ Hand data is not necessarily required for walking motions

→ But hand data is required for grasping motions

Q & A: MMM

- Using limited MMM data for simulation of prosthesis wearers

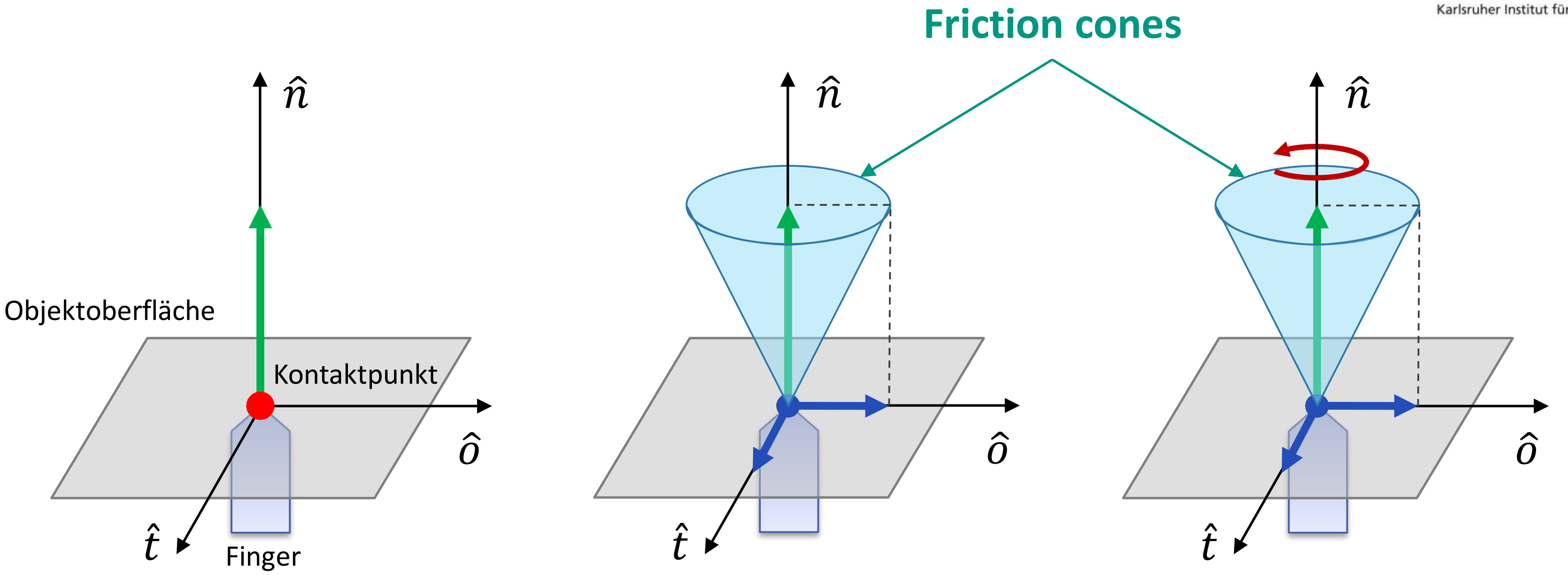


Q & A: Grasping

- **Q1:** What does “soft” mean in terms of the dynamic behavior of a grasp?
- Soft here refers to the impedance of the fingers of a robotic hand to perform e.g. manipulation tasks

- **Three contact models** (see Lecture Robotics I, Chapter 08)
  - Rigid contact without friction (only normal force at contact point)
  - Rigid contact with friction (normal and tangential forces at contact point)
  - Soft contact (normal and tangential forces as well as axial torque at contact point)

Contact models



Rigid contact without friction
(normal force)

Rigit contact with friction
(normal and tangential forces)

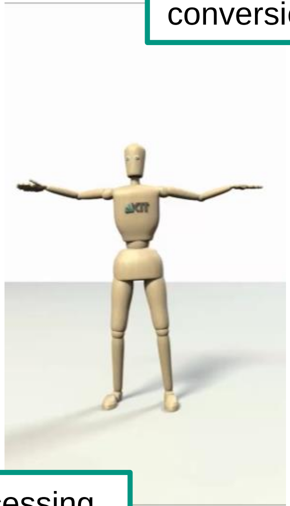
Soft contacts
(normal and tangential forces as well as axial torque at contact point)

Q & A: Grasping

- **Q2:** Can the measured motion data be directly transferred to the MMM model or do you need some manual adjustments?

- Manual adjustments depend on the quality of the input data
- Example: VICON data
  - semi-automatic post-processing of the VICON data (add missing markers, label them)
  - conversion to MMM happens automatically (using non-linear optimization), given a human specific configuration
  - conversion from MMM to a virtual robot happens automatically (using non-linear optimization), given a robot specific configuration
  - transfer the virtual robot motion to the real robot one usually needs further adjustments, to consider further aspects e.g. dynamics

Q & A: Grasping



1. VICON data post-processing.
2. Use **NLopt** and human specific configuration for automatic conversion to MMM

Use NLopt and robot specific configuration for automatic conversion

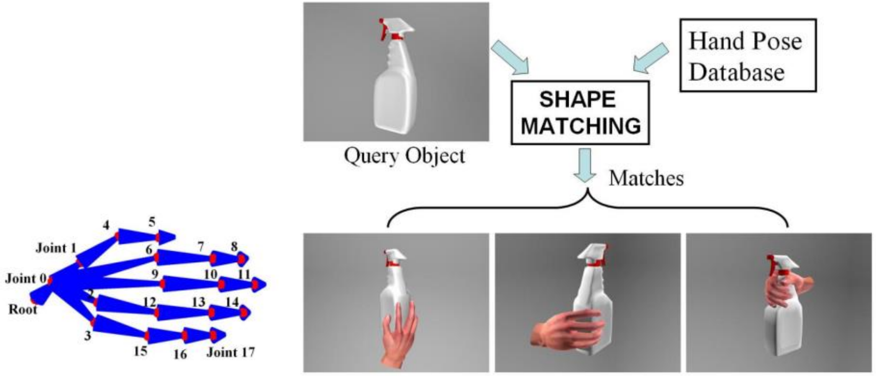
Adjustment:
Torque in the ankle

NLopt: https://nlopt.readthedocs.io/en/latest

Q & A: Questions from last lecture

- **Q1:** How to match the syntesized grasps from the shape matching algorithm to the robots kinematic?

- Shape matching process
  - Query: new object model
  - Find: Hand pose with matching/similar contact points and normal
- This method only finds grasps for a specific hand model (human-like)
- **To generate grasps for robots, one must convert the grasp to match the robot structure**



Y. Li and N. Pollard, **A Shape Matching Algorithm for synthesizing humanlike enveloping grasps**, in Proc. IEEE/RAS Int. Conf. Human. Robots (Humanoids), Dec. 2005, pp. 442–449.

Q & A: Questions from last lecture

- **Q2:** Does „familiar“ also mean that an object may have a maximum size?

- E.g. Cups and Tons have a simiar form but different sizes
- Deciding whether an object is familiar to a known one depends on the size of the object
  - E.g. A small hand cannot grasp the ton while a very big hand would probably use a precision grasp to grasp the small cup → different grasps

www.amazon.de
WandKings

www.ikea.de

- **Q3:** Is grasping unknown objects necessary even if we have a very large training set?

- The space of possible object shapes is infinite
- Further: Storing all kinds of objects is memory-instensive and unatural (humans also are able to infer new grasps for unkown objects)

Q & A: Questions from last lecture

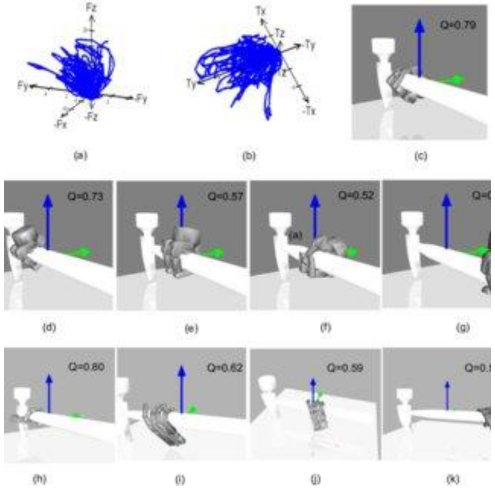
- **Q1:** Is there a way to „learn“ the classes of grasp types, like done in ASR systems?

- The older systems used taxonomies to distinguish the grasp types. This works quite good, since these taxonomies are based on real human data.
- Of course it is also possible to learn classes of grasps
  - See e.g. Grasp2Vec: Learning Object Representations from Self-Supervised Grasping https://arxiv.org/abs/1811.06964

Q & A: Questions from last lecture

- **Q2:** What is meant by the functionality of an object?

- E.g. You do not grasp a hammer at the head. You usually use the stick since you want to use the hammer (its functionality)



Q & A: Questions from last lecture

- **Q1:** Is there a new edge for every invalid contact change in the whole-body taxonomy with multiple contact relation changes?

- No, if there is a relation change which cannot be explained, then we only record it since we cannot know which relation changed first.

Q & A: Questions from last lecture

- **Q2:** What is the benefit from imaging objects rather than grasping real objects?

- The authors wanted to analyze how humans prepare their grasps. Using no objects at all fully focusses the recorded data on the grasp preparation

- PS: You saw the results of the exercise sheet: Since we used real objects the data was indeed different

Q & A: Questions from last lecture

- **Q1:** What is the difference between the efficient plan execution and the information gathering in haptic exploration?

- The efficient plan execution takes care that we do not generate a „next-best-touch“ far away. It prefers points near the current location of the hand.
- The information gathering step ensures that we collect as much data as possibe although we may not need the information (position, normal vector, surface friction, ...)