Complementary Strengths of Learning and Planning

- **Challenge:** Motion generation for goal-directed robotic assistance
- **Proposed methods:**
  1) Motion reproduction from demonstration
     + No explicit environmental model
     + Implicit dynamical task model
     + Scales to high degrees of freedom
     + User-adaptive
  2) Feedback motion planning
     + Plan for entire accessible region
     + Computationally tractable in 6D
     + Short and collision-free paths
     + Reactive to user-induced deviation
- **Fusion for the best of both worlds**

Disagreement-Aware Assistance

- **Understanding human sensorimotor behavior as a source of variability**
- **Novel control concept based on risk-sensitive optimal feedback control with cost function**
  \[ \gamma(\theta) = -2\theta^{-1} \ln E[\exp^{-\frac{1}{2} \theta J}] \]
- **Observation of past and current process noise interpreted as disagreement**
- **Intuitive assistance behavior considering prediction uncertainties of the task model and process noise**

Dynamic Allocation of Roles

- **Humans dynamically negotiate the effort distribution**
- **Effort sharing by geometrical wrench decomposition**
  \[ \hat{u} = G^+ \hat{u}_c + \sum_{j=1}^{\text{nullity}(G)} \lambda_j \mathbf{K} \mathbf{r}_j(G) \]
- **Dynamic role changes by interpreting human feedback as agreement and varying \( \lambda_j \)**
- **Weighted pro-active (WPRA), discrete (DPRA) and constant (CRA) role allocation scheme evaluated in a large-scale HR-study\(^1\)**
- **Role schemes affect cooperation, yielding a trade-off between subjective acceptance (CRA best) and objective performance criteria (WPRA best)**

Rapid Prototyping Environment

- **Development of pHRI-capable robots requires robust, flexible and safe experimental systems**
- **VR-system for 2-DoF visuo-haptic rendering (left)**
- **6-DoF mobile manipulator for realistic full-body kinesthetic interaction (right)**
- **Driven by modular real-time software architecture**

Selected publications: