

A transfer project of the SFB/TRR 62 "A Companion-Technology for Cognitive Technical Systems" University of Ulm | Robert Bosch GmbH

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# **A Digital Companion for DIY Projects**



- Support novice users with setting up DIY tools and completing DIY projects
- The DIY domain
  - requires proficiency with electric and manual tools, attachments and different materials
  - ► different possible courses of action towards a goal are possible
  - unforeseen events might occur during task execution (e.g. mistake, tool breaks, etc.)

# **Underlying Technologies**



- We combine
  - ► (hierarchical) Al planning
  - ontology-based knowledge modeling
  - multimodal human-computer interaction

#### **Application Scenario**

- Step-by-step instructions enable users to achieve different tasks
  - Planning techniques allow for adapting to individual situations and preferences
- Explanations enable users to learn about the application domain and the device(s):
  - ► How are devices and objects in the domain distinguished?
  - ▶ What characterizes them?
  - ▶ What device can be used for which task?
  - ▶ Which settings, equipment, etc. are needed to perform a task?

# **Step-by-Step Assistance**



- Each step is illustrated by text, image and video
- Speech, text and touch commands for navigation and information requests
- Questions about concepts, appearance of objects, etc. supported

# **Robert – An Adaptive DIY Assistant**







- Integration of procedural and declarative knowledge
- Ontology as (unified) underlying knowledge source for planning and dialogue
- Interaction realized using dialog agents and a multimodal GUI



# System Components – Dialog and User Interface Domain Model



- Dialog management controls interaction between user and assistant components (planner, ontology):
  - Selection of appropriate system actions
  - Transformation of formalized concepts into natural speech
  - Initiation of proactive dialog

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#### **Robert's Dialog Management**



- Separation of user interface and dialogue control:
  - Client: multimodal user interface
  - ► Server: agent-based dialog management
- Exploitation of cloud-based cognitive services:
  - Automatic speech recognition and text-to-speech synthesis (Google web speech)
  - Language understanding (RASA NLU)





 Individual Cloud-Based Natural Language Understanding (NLU) of user input (RASA NLU)

- ► Dialogue Agent with best NLU result selected
- Activation of respective Dialog Handler for processing user request and communication with assistant components





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#### **Activity Recognition with the Connected Tool**



PSR18Li2 prototypically equipped with

- IMU (inertial measurement unit)
- WiFi development board

Activity classifier

- Neural network architecture based on CNNs and LSTMs (cf. Ordoñez & Roggen 2016)
- Trained using labeled data from experiment (12 participants)

# Recognized (disjoint) **activity classes**:

- drilling
- screwing
- running (idle)
- drill change
- battery change
- being moved
- off/resting

#### **Activity-Triggered Interaction**

- User picks up tool:
  - You seem to be working with the connected tool for the first time.
  - Don't worry, I'll guide you through the steps!"
- As soon as battery change, drilling, drill change, or screwing are detected:
  - "I noticed that you were [changing the battery/drilling/changing the attachment/screwing]. Did that work?"
- Inactivity (3 minutes):
  - "I haven't seen any tool activity by you in three minutes. Do you need help?"

# **Robert's Dialog Management – Connected Tool**







- Robert's Planner generates an individualized plan for the DIY project
- Considers the currently available tools and materials
- Adapts the plan exactly to the situation
- Provides a step-by-step plan

#### **Hierarchical Planning**

- Planning is the task of finding a course of action which satisfies a desired goal when executed.
- In hierarchical planning this is done by step-wise refining initially given abstract tasks into more fine-grained actions the user can execute.



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#### **Robert – An Adaptive DIY Assistant**





- Robert generates a hierarchical plan
- Allows for
  - ► showing the plan in different levels of granularity
  - adapting the plan to the knowledge of the user



# **Robert – An Adaptive DIY Assistant**





- Generated instruction might not be the preferred one of the user
- Robert allows for changing the plan
- Changes are performed such that the resulting plan is still sound and complete
- In the background the change request is translated into a formula in Linear Temporal Logic





The ontology manager handles declarative knowledge

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#### Modeling DIY Domain Knowledge

 Domain Ontology Models general knowledge about DIY tools and materials:

spruce *is-a* softwood softwood *is-a* wood wood *is-a* material



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# Knowledge about Actions and Media Contents Instruction Ontology Models knowledge about the possible actions and their media contents in the DIY domain: attach a battery to the PSR18Li2



Slide the battery onto the handle of your PSR18Li2 until it locks into place.

Stecken Sie den Akku auf den Griff Ihres PSR18Li2 bis er einrastet. Page 25 Do it yourself, but not alone: Companion-Technology for DIY Assistance

#### **System Architecture**

Reasoning and background knowledge allows for inferring suitable alternatives if an exact match for an instruction is not available

insert the 3 mm bit into the PSR18Li2 

insert a bit into the drill



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#### **Enriching the Planning Model**

 Valid combinations of tools, materials and settings are inferred and passed to the planner

For establishing a screw connection in softwood with a 4 mm screw, pre-drilling with 3 mm diameter and a moderate speed is appropriate



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#### Verbalization

 Natural language explanations and descriptions are automatically generated

Spruce is softwood, thus, screwing a 3 mm screw in spruce applies to softwood. By definition, a 3 mm screw is a small screw. Screwing a small screw into softwood does not require pre-drilling. Therefore, screwing a 3 mm screw into spruce does not require pre-drilling.



# Verbalization

 Natural language explanations and descriptions are automatically generated



