kuk-A-droid

1. Cover page

a. Project full title and short title/acronym

Kuk-A-droid: your mobile manipulator buddy

b. Applicant contact data

i. Name of project leader

My name is Arnaud Bertrand and here are my contact informations:

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ii.Institution of project leader

In this project I only represent my-self. If any structure affiliation is required, I may create one especially for it.

c. Short summary of project proposal

The aim of this project is to provide youBot with cognitive capacities and behaviors to make it as close to humans as possible. To achieve this result, I will develop a speech interface to interact in natural language. The robot, dubbed kuk-A-droid, will be given an affective awareness and will be able to behave accordingly with its body expression.

I hope that this project will help to develop a personality for youBot, which is a sensational piece of hardware, but a little bit disturbing with it's single arm on the back and its two fingers.

Most of the development will be supported by a mobile phone running Android. This technical option will be motivated in the chapter 4 (to be very clear, this project is not another Android based remote).

Finally, this project can be classified in the field of Human-Robot Interaction. All those new skills are supposed to trigger empathy, from a robot shape far from the humans (no eye-contact possible, no humanoid shape). This is my challenge.

2. Team description (max. 1 page)

a. Institution / Laboratory / Group description

Alone at the time this document is written.

b. Background in mobile manipulation (experience, projects, …)

Well, none in fact, except an extensive reading in the past months.

I have interesting assets through, like a strong background in mathematics, physics and project management. I also have very goods programming skills in C/C++, Java and Python. I'm also an experienced user of Linux and Ubuntu in particular.

3. Motivation and objectives

a. General description of industrial and scientific challenges to be tackled (relating to an application of mobile manipulators and/or the development of specific components/algorithms for a mobile manipulator)

The first challenge is the natural language interaction. Speech should be processed, understood and should trigger appropriate reaction and actions from youBot. Targeted reactions are specific to mobile manipulation.

Another challenge typically correlated with human-robot interaction is computer vision. Vision will be the main sensor: it will be used for obstruction avoidance, object and face recognition, speaker localisation, etc.

Natural language processing and computer vision require high-end competencies. The aim of this project is not to enhance those field. I will only benefit of what has been fantastically developed by others.

Technically speaking, the project challenge is mainly an integration of existing components. All components should run on the Android platform. Current smartphones are powerful computers, but resources will therefore be limited. I accept this constraint and I see also big advantages and opportunities.

b. Objectives of the proposed work

The project is splitted into several specific objectives, with several levels of difficulties. The most challenging ones may not be reached in the timeline of the project. Some may be done after, or by others, the openness of the project being an objective by itself.

At any moment, kuk-A-droid could be in one of following state: interactive, autonomous and at rest. Each objective is assigned to one of this state.

Objective 1: interactive mode, including the definition of a set of body expressions specific to the shape of youBot, response to simple vocal command. Kuk-A-droid will show some empathy and will adapt his behavior and body expression to the psychological state of the humans around it. Kuk-A-droid will be affective aware. This is a key objective to leverage the acceptation rate of robots in human workspace and develop future collaboration.

Objective 2: simple autonomous life, basically an obstacle avoidance behavior. The transition from and to the previous state is included in this objective. This objective includes the definition of a “at rest” state.

Objective 3: create a communication module between ROS and Android OS. The intelligent part of the code should be located on the mobile device for reusability on other robotics platform.

4. Approach and realization

a. Technical details of proposed solution including a description of the work the project capitalizes on and why the proposed solution is promising

As a general comment, this project will be pragmatic. That means that the plan is not to create a digital life, but to fake it. That also means that workarounds could be applied for quick results.

A large part of this project will be based on Android OS. This platform is interesting when it comes to robotics. The devices that run it are by nature mobile, and so they are already efficient computers and yet powerful (CPU 1.2 Ghz dual core + GPU 512 Mhz for the Galaxy Nexus). They can be easily replaced when newest models are available (which is frequent).

Moreover, they are equipped with a bunch of sensors for measurement of :

- motion like acceleration and rotation with accelerometers and gyroscopes
- environment like illumination (popular), pressure or temperature (less common)
- position with GPS and orientation with magnetometers
- distance (low range only)

To this list should be added the following interesting features:

- 1 HD and 1 SD camera / HD display
- audio microphone and speaker
- full range of wireless connexion, WiFI, bluetooth and mobile phones networks
- NFC (could be used to trick object localisation)

Of course Android mobile devices are broadly available (900 million devices activated as of May 2013, 1.5 million activation a day), relatively cheap compared to standalone sensors, which is attractive for starting in robotics. The technical framework itself has several strong assets. It is based on Java, a professional grade development environment. C++ applications can also be

developed for specific requirements. Android is open, the documentation is largely extensive, so is the community of developers behind. Voice recognition is native. The mobile device will communicate with onboard ROS through USB and send commands or receive data.

A set of body expressions will be defined, at least for the following emotions: interest / calm / happy / sad. The arm position and movement, the platform motion and eventually the screen of the mobile will be coordinated to trigger the expected effect. This work could use real-life behavior that can be found in the nature or be created from scratch. Crowdsourcing could be used to confirm that the behavior is perceived properly by people out of the project.

Example of behavior: kuk-A-droid will come close the speaker, stay in front of him, acknowledge if understood.

Additional emotional states will be added in the project timeline or after. The four mentioned earlier are sufficient at the beginning. Anger and disgust will be the next ones, as they will strengthen the personality of kuk-A-droid.

Computer vision will be highly involved, as the camera will be the main sensor for short distance. Obstacles can be avoided using optical flow technique. Secondly, faces can be detected, and even affective state of the surrounding humans. Ideally existing libraries will be called for all those high-end features.

b. Work plan (milestones and intermediate results including use of resources)

Milestone 1: Android-ROS communication through USB. A simple program will be develop to confirm the correct connection to the API.

Milestone 2: define body expressions for the identified emotions. The first part of the SEE (Stanford Engineering Everywhere) online course “Introduction to Robotics” will be studied. A theoretical study will be carried out in the Grazebo simulator, before implementation in a real robot. This milestone can be undertaken in parallel of the first one.

Milestone 3: autonomous behavior and obstacle avoidance using computer vision. The second part of the SEE online course “Introduction to Robotics” will be studied. The completion of the first milestone is required for this third milestone. Milestone 1 should be achieved to start working on the milestone 3.

Milestone 4: response to simple vocal command. The transition between autonomous and interactive states conditions will be defined. This milestone will be done on very simple command, like “hello kuk-A-droid or “come close”. One of the main knowledge resource for this milestone will be the SEE online course “Natural Language Processing”. All previous milestone are required to start working on the milestone 4.

Milestone 5: develop affective awareness and adapt body expression accordingly. Kuk-A-droid

will be able to analyse several kinds of cues. The several emotions states will be implemented one by one. Milestone 4 should be achieved to start working on milestone 4.

Milestone 6: respond to complex order. Such orders could be “Grab something”. The localisation of objects could be tricked using NFC.

c. Used hardware (sensors) and software (libraries, licenses)

The mobile device will be a Samsung Galaxy Nexus. All sensors of this device may be used. Here are a few characteristic:

- SoC Texas Instruments OMAP 4460 = CPU 1.2 GHz dual-core ARM Cortex-A9 + GPU512 MHz PowerVR SGX540
- rear camera of 5 MP (2592×1936 px) Autofocus, zero shutter lag, 1080p video recording, (1920×1080 @ 24 fps)
- front camera of 1.3 MP, 720p video (1280x720 @ 30 fps)
- dual microphones for active noise cancellation

The following libraries will be directly used (all Open Source licensed):

- Android 4.2.2 Jelly Bean
- ROS / OpenCV
- Grazebo (robot simulator)
- Attention Meter

Additional libraries may be added afterwards, once objectives and milestones studied in detail. Best effort will be done to only involve Open Source software.

Just to mention them, the following tools/OS/application will be used:

- Android Studio for Android development
- Windows 7 / Chrome / Google Drive
- Ubuntu
- Java / Python (IDLE) / C++
- GitHub

5. Results and measures of success

a. Results

The expected results in the timeline of the project are responses to “hello kuk-A-droid” and “come close”. Enough body expressions to make feel that kuk-A-droid is able to have several psychological states, even if not perfectly translatable to the target emotions.

b. Assessment of technology readiness level of the proposed solution including its scalability and the reusability of used and developed components

The Android platform is completely “ready”. This option is the key for the scalability and the reusability of the developments. All functions directly and autonomously supported by the mobile device could be transferred to another robot.

For other functions, like the set of body expressions, they should be redefined with the specific shape of the new host. I hope to be able to draw some general guidelines for doing this work on another platform.

Regarding the computer vision, which will be intensively used, some commercial applications already exist, especially face recognition and smile detection (for triggering shots). It is also applied in many experimental systems, with a pretty high level of readiness, between demonstration and full qualification in realistic environment.

6. Economic analysis of proposed solution

a. Analysis of economic impact

At a first level, the economic impact could be good, considering the rising number of robots available today. Take for examples the Roomba from iRobot or the Pioneer 3-AT from Adept Mobilerobots. The development proposed in this project could be translated to them. Let’s imagine that you order your Roomba to clean a given room.

Mobile phones will become cheap sensors for such robots, with advanced functionalities. This is an low-cost entry for anyone interesting in robotics. You can start facing robotics challenge just with your phone.

For the long term, I strongly believe that robots should and will acquire social skills, that will help them to be more accepted. This will leverage the symbiosis between them and the humans. The evolution will be similar to the one of the computer, from a monolithic and distance machine to a versatile and handy companion.

b. Analysis of competitive advantage

The main competitive advantage is the mobile device in a central position and the Android OS. Even if the sensors are not the best, they cover a large spectrum of features, especially video and microphones.

Android OS is open. The development kits are free and based on standard technology. The number of developers is huge and pulled by Google Play (the Android app market).

I’m obviously not the first to have thought about that. Google and Hasbro have released 2 years ago a robot-toy based on Android. Cellbots is an open source project that succeeded in controlling low-cost robots with cellphones. Finally, a few days ago, Apple announced sponsoring Anki, which planned to deliver robots controlled by iPhone and bring to the entertainment industry advanced techniques from robotics.