CogLaboration

Collaborative Project

FP7 – 287888

D2.10: Report on Scenarios, Tasks and Goals

Lead Author: Geoff Pegman
With contributions from: UOB, RUR
Reviewer: Anthony Remazeilles (Tecnalia), Víctor Fernández (Treelogic)

Deliverable nature:	Report (R)
Dissemination level: (Confidentiality)	Public (PU)
Contractual delivery date:	29th February 2012
Actual delivery date:	29th February 2012
Version:	1.0
Total number of pages:	19
Keywords:	Specification, Scenario, Task, Goal, Fluent Transfer, Experiment, Human-human trials, Robot-human trials

Abstract

This report describes two scenarios that mirror real life situations in which fluent passing of objects is critical for robot assistants to be accepted in society. The two scenarios are based on a car mechanic working in a small garage and an elderly person being given assistance with activities of daily life in her own home. In addition a range of common objects for these two scenarios have been defined and a series of tasks to be carried out during the evaluation trials have been described. This work forms the basis of a performance requirement against which the design of the full CogLaboration robot system can proceed, including the final definition of performance measures, preparation for the human-human object exchange trials, preparation of the robot system, development of the evaluation protocol and the final design of robot-human trials layout.

Executive summary

This document describes the overall scenarios guiding the CogLaboration project activities. It also describes the main tasks that will be used to define the experiments along with the objects used in those tasks. The descriptions proceed from an analysis carried out by RUR and UOB. This analysis aimed to provide a series of tasks that would allow a full range of passing actions to be investigated and compelling scenarios in which they could be situated.

Two scenarios have been defined. The first is based on a car mechanic working in a small garage with only a small number of staff. Although the garage is equipped with a hydraulic lift it is not always possible to work on a car on the lift. Therefore three sub-scenarios have been defined, namely lying underneath a car, reaching into the engine bay and working underneath the hydraulic lift. The second scenario concerns the provision of assistance to an elderly person in their own home for undertaking typical activities of daily life. The elderly person is likely to have frailties including, possibly, deficiencies in the sense of touch, sight deficiencies and weakness of the limbs. The sub-scenarios defined are with the person standing while supporting themselves with a walking stick and with the person sitting.

For each of these scenarios a series of objects to be transferred have been defined. In the case of the car mechanic these are typical tools that might be found in a garage that allow for the performance parameters to be evaluated over a range of object characteristics. Therefore these objects vary in both size and weight as well as in terms of whether they have a specific grasp position for the user.

Next a set of tasks have been defined which are common to both scenarios. The basic idea is simply that the object should be passed to the person by the robot and the robot should receive back an object from the person. However, these tasks are expanded to form a series of sub-tasks which can be put together to form specific experiments.

Finally an early indication of the likely performance measures is given. Although these are not a requirement for this report, they do help to frame the context of the experiments and thus give a better idea as to the likely usage of the system in the experimental setting.

This report provides the baseline against which the design of the experiments can be undertaken. It also provides a first draft of the performance requirement against which the design of the robot system (including the hand and vision system) can proceed.

Document Information

IST Project Number	FP7 - 287888	**Acronym**	CogLaboration
Full Title	Successful Real World Human-Robot Collaboration: From the Cognition of Human-Human Collaboration to the Cognition of Fluent Human-Robot Collaboration		
Project URL	http://www.coglaboration.eu/		
Document URL	http://www.coglaboration.eu/node/33		
EU Project Officer	Juha Heikkilä		

Deliverable	**Number**	D2.10	**Title**	Report on scenarios, tasks and goals
Work Package	**Number**	WP2	**Title**	Cognitive Principles of Human-Human Collaborative Object Exchange

Date of Delivery	**Contractual**	28 February 2012	**Actual**	M04
Status	version 1.0		final **x**	
Nature	prototype □ report **x** demonstrator □ other □			
Dissemination level	public **x** restricted □			

Authors (Partner)	RUR			
Responsible Author	**Name**	Geoff Pegman	**E-mail**	geoff.pegman@rurobots.co.uk
	Partner	RUR	**Phone**	+44 161 799 3898

Abstract (for dissemination)	This report describes two scenarios that mirror real life situations in which fluent passing of objects is critical for robot assistants to be accepted in society. The two scenarios are based on a car mechanic working in a small garage and an elderly person being given assistance with activities of daily life in her own home. In addition a range of common objects for these two scenarios have been defined and a series of tasks to be carried out during the evaluation trials have been described. This work forms the basis of a performance requirement against which the design of the full CogLaboration robot system can proceed, including the final definition of performance measures, preparation for the human-human object exchange experiments, preparation of the robot system, development of the evaluation protocol and the final design of robot-human trials layout.

Keywords	Specification, Scenario, Task, Goal, Fluent Transfer, Experiment, Human-human trials, Robot-human trials

Version Log			
Issue Date	**Rev. No.**	**Author**	**Change**
22-12-11	0.1	Satoshi Endo	First Draft
19-01-12	0.2	Geoff Pegman	Second Draft
24-02-12	0.3	Geoff Pegman	Preview Version
26-02-12	0.4	Treelogic	First Review
27-02-12	0.5	Tecnalia	Second Review
29-02-12	1.0	Geoff Pegman	Final Version

Table of Contents

List of figures and/or list of tables

Abbreviations

A list of abbreviations in alphabetical order is strongly recommended. See the following example.

ADL: Activities of Daily Living

RUR: R U Robots Limited

UOB: University of Birmingham

1 Introduction

This document describes the overall scenarios guiding the CogLaboration project activities. It also describes the main tasks that will be used to define the experiments along with the objects used in those tasks. The descriptions proceed from an analysis carried out by RUR and UOB and involved a series of consultations with the rest of the consortium. This analysis aimed to provide a series of tasks that would allow a full range of passing actions to be investigated and compelling scenarios in which they could be situated.

1.1 Scenario Overviews

The CogLaboration proposal listed two Scenarios to guide the project work, that of a carpenter (i.e. a professional workplace setting) and that of an elderly person (a domestic setting). In reviewing the range of tasks and scenarios it was decided that the carpenter scenario did not provide for the full range tasks and action types to test the range of fluency of object passing tasks nor did it provide the most compelling reason for engaging with a CogLaboration type system. Having analysed various scenarios it was decided that a car mechanic scenario better fitted this role. The two sections below give the outline scenarios in an easily accessible form.

1.1.1 Car Mechanic

John owns a small car repair garage where he services all kinds of cars from the local area. Pride of place in the garage used to be his hydraulic lift but now it is the new Coglaboration robot he had just bought. His main reason for buying the robot was that he got frustrated every time he was underneath the car and found that he did not have the right tool with him he had to slide back out, go and get the tool and then slide back under again. Now he didn't have to worry about that at all as he just requested the tool he wanted, stuck his hand out and the CogLaboration robot brought it to him. In fact it didn't just make it easier when under the car, whether he was working on the engine with the bonnet up or even under a car on a hydraulic lift, it was much easier to have the correct tool brought to him than going to find it. Also he found that he could focus more on the task he was doing and get jobs done much faster. The fact that the robot passed across these tools in a natural and fluent manner had surprised John, but it really helped him accept it as an assistant, rather than a piece of machinery. It was safe too; For sharp tools like saws the robot always made sure that John could get hold of the handle. The robot can even hand over a mug of tea in a safe manner! This fluent object exchange capability of CogLaboration has sped up John's work and increase his productivity.

1.1.2 Elderly Person at Home

Dora is 75 years old and her sensorimotor functions are dramatically reduced. In particular, she finds difficult to move her body and limbs quickly, carry heavy objects, bend down to pick objects from the floor or stretch to reach object located on high shelves. Fortunately, after she underwent some self-independency tests, her healthcare provider installed a new CogLaboration robot designed to locate and hand over objects to her upon request. The robot can use its awareness about Dora's sensorimotor abilities and hand over objects to her in a manner that suits her; therefore, achieving 'personalised' fluent object exchange. For example, CogLaboration knows about the weight of certain objects and judge whether Dora is strong enough to handle it. If it realises the object is too heavy then he can or warn of the risk of dropping the object. Moreover, CogLaboration knows that some objects are likely to be hot and issues warning or take extra care when handing them over. For example, when he carries a hot drink, it handles it in a way that leaves the handle of the cup visible, accessible and easily graspable by Dora. Dora has found CogLaboration very useful and has regain her self-independency.

2 Scenarios

Two Scenarios have been identified which include a range of task positions and parameters. One is in a professional workplace setting (a car mechanic) and the other in a domestic setting (support for an elderly person). These scenarios have been chosen because the project is convinced that they correspond to two domains in which such a robot system could be beneficial, they span the range of professional and domestic use and they present the opportunity for a wide range of physical postures and situations to be investigated. These are described in the section below.

2.1 Car Mechanic

The Car Mechanic scenario is meant to provide an environment which simulates a professional working situation with a skilled worker, albeit one that has more freedom and flexibility than many manufacturing plants. The worker does not have any significant disabilities or frailties. The scenario involves three different working positions, these being lying under the car, working in the engine bay and working underneath a car on a hydraulic lift. In each of these situations the worker will request tools and pass back tools and the requirement of the robot is to pass or receive these tools in a fluent manner.

2.1.1 Lying under the car

In order to simulate lying under the car it is necessary to exert three constraints on the situations, namely:

1. The user's view of the surroundings in extremely limited and s/he will be relying greatly on the sense of touch as the primary means for enacting the passing manoeuvre.
2. The user's range of arm motions will be limited by the fact that s/he will be lying on their back and the torso will have limited movement, although the arm will be free to move.
3. The robot will have a limited view of the person, although most of the arm should be in view from the start of the experiment until after the object has been transferred.

To simulate this scenario a base will be provided on which the person will lie which will be at least 1m wide (this may be raised off the floor to facilitate the experimental set up with the robot and cameras, etc). A matching sized panel will be placed no more than 500mm above this platform to represent the underside of the car. The box thus formed will (at least) be open on one end and one side, enabling the user to enter from the bottom and put one arm out to their right side. Movement in and out of the box could be facilitated by a mechanics creeper trolley but then the height of the top panel would need to be adjusted to account for this. A task box will be incorporated in the upper panel at the approximate position of the user's head. The details of an appropriate task box will be investigated during T2.3 although wooden threaded dowels and wooden nuts would be appropriate. However, safety considerations may limit this to buttons and LEDs.

2.1.2 Working in the engine bay

This scenario has more free access than the previous one, although there are still some constraints on the user, namely:

1. The user will be bending over the task area and will try and maintain contact with the simulated engine throughout the passing tasks. However they will be able to view the passing manoeuvre.
2. The user will be slightly limited by their posture and will generally be reaching backwards, restricting the full range of motion during the passing manoeuvre.
3. The robot will have full view of the person and their arm.

To simulate this scenario an open frame will be provided. For the sake of illustration this could be approximately 1m tall and 2m square, but the experimental setting will dictate the setting. The bonnet of the car will be simulated by an opaque of, say, 2m square screen rising at approximately 60^0 from the far edge of the frame. A task box will be set into the frame approximately 200mm down from the top edge and approximately 400mm square. The details of an appropriate task box will be investigated during T2.3 but peg in hole and threaded nut insertion tasks would be appropriate.

2.1.3 Working under hydraulic ramp

This scenario has yet more freedom of access, although again some kinematic constraints are placed on the user. The main constraints are:

1. The user will be reaching slightly above head height and will be trying to maintain contact with one hand with the “car”. The user will be free to look at the passing manoeuvre.
2. The user will be slightly constrained by the requirement to keep one hand on the “engine”, although this will not greatly effect the free range of movement of the other arm but will constrain the degree to which the back can move to participate in the motion.
3. The robot will have full view of the person and their arm.

To simulate this scenario an open frame will be provided, approximately 2m tall and 2m square. However the height will be adjustable over a range of approximately 400mm to provide a comfortable working height for the users. A task box will be set into the frame at the height of the top edge and approximately 400mm square. The details of an appropriate task box will be investigated during T2.3 but peg in hole and threaded nut insertion tasks would be appropriate.

2.2 Assisted Living in a Domestic Setting

The domestic scenario is meant to provide an environment which simulates the provision of support of ADL to an elderly person living in their own home. The person is elderly and may have haptic (sense of touch and force) and/or visual impairment and may also have a physical weakness of the muscles. Whether or not these are simulated in the trials the robot should be aware of these conditions and modify its behaviour appropriately. Other than the setting, the main difference is that the user is likely to be a non-technical person, may have some sensorimotor frailty and is likely to have a more relaxed sense of urgency. This scenario involves two different working positions, standing and seated. In each situation the person will request an object or hand back an object and the requirement of the robot is to pass or receive these objects in a fluent manner, consistent with the known state of physical capabilities of the person.

2.2.1 Standing position

In the standing position the person can be assumed to be supporting themselves with one arm (the left) using a walking stick, zimmer frame or piece of furniture. No other restriction is put on the scenario. The person will, to the extent of their physical abilities, be capable of viewing the passing manoeuvre and of interacting freely with the robot. The robot will also be capable of unrestricted viewing the whole person including their arms.

To simulate this scenario a walking stick may be provided, which will restrict the range of movement available to the user.

2.2.2 Sitting position

In the sitting position the person needs no other support and can freely interact with the robot. The person will, to the extent of their physical abilities, be capable of viewing the passing manoeuvre and of interacting freely with the robot. The robot will also be capable of unrestricted viewing the whole person including their arms against the background of the chair. A variant of this task is where the person is sitting up in bed. Here the main restriction is that all the interactions must take place to the right hand side of the person as the bed will restrict direct access in front of the person. By contrast, when sitting on a chair where the interaction could take place directly in front of the person.

To simulate this scenario the person will be seated on an ordinary office chair. For the optional sitting up in bed scenario a footstool or pouffe will be provided on which the user can rest their feet, which will also create a similar access restriction to the bed.

2.2.3 Sensori-motor deficiencies

This is not a separate sub-scenario, but it is of interest to the project to simulate some of the sensori-motor deficiencies that may be encountered in the assisted living tasks and therefore this is an additional option to be applied to both the sub-scenarios described above. Three areas will be considered; haptic impairment, visual impairment and physical weakness. The potential benefit and means of simulating such deficits will be evaluated during T2.3. However, the first could be addressed through the use of thin gloves. Visual impairment could be addressed through the use of glasses to blur the vision, or simply by asking the users to close their eyes. Physical weakness could be simulated through additional weight to the objects, although there are practical limits to this arising from safety concerns and robot weight limitations. It is important to state that for the purposes of all experiments fit and healthy adults will be utilised.

3 Objects to be Passed

This section details the type of objects to be passed during the trials in each scenario and covers both the human-human trials and the robot-human trials. It should be considered a minimum list. The objects have been chosen to be representative of the range of objects that might be required in each scenario but also because they are amenable to experimentation from the point of view of robot manipulation, vision system recognition and tracking and instrumentation. The appropriateness of each object will be further assessed during T2.3. Because each scenario is different each set of objects is considered only for the particular scenario.

3.1 Car Mechanic

In the case of the car mechanic there are a number of tools and objects proposed which will enable the variables of the passing task to be tested and evaluated across a wide range of the performance spectrum. Some of these form the core requirement but some others are optional suggestions which could help the investigation of the performance space. In particular the nut and bolt may be problematic for the vision system but will be still useful to see how such small objects could be effectively transferred with the Coglaboration system. These are detailed in Table 1 below:

Table 1: Objects for Car Mechanic Scenario

Object	**Preferred Human Grasp Point**	**Applicable Sub-Scenarios**	**Comments**
Spanner / Wrench	Mid-point (Non-essential)	All	Suggest a range of spanner sizes e.g. 10mm, 13mm & 19mm with open jaw at one end and ring spanner at the other.
Rubber Mallet / Hammer	End of handle (Non-essential)	All	Suggest both small head (hammer) and large head (Mallet) are considered
Hacksaw	Handle with blade pointing away from person (Essential)	All	Blade can be replaced with a length of wire for safety
Pliers	Handle with jaws closed (Non essential)	All	
Power drill	Handle with drill pointing away from person (Essential)	All	The power drill does not need to have an electric cord attached
Pneumatic Wrench	Handle with wrench pointing away from person (Non-essential)	Working in Engine Bay Working under Hydraulic ramp	The pneumatic wrench tests handling of heavy objects as it is significantly heavier than power drill
Torch	Body of torch (Non-essential)	All	
Light	Mid-point on body of light (Essential)	All	This is an optional item. The light is to have a short cord attached to simulate the power cord. This is to show that, in principle, power cords can be

Object	Preferred Human Grasp Point	Applicable Sub-Scenarios	Comments
			handled by the system. However, the aim of the project is not to solve cord handling issues.
Nut and bolt	Placed in palm of hand (receiving) or in first finger-thumb pincer grip (giving).	All	An optional item if the system capabilities allow. Suggest size M12 (fits with 19mm spanner)
Small tray or box containing nut or bolt	One edge of box or tray (Non-essential)	All	An optional item
Mug of tea / coffee	Handle (Non-essential)	Working in Engine Bay	The mug is to be empty. An option is have the mug three-quarters full of cold liquid.

3.2 Assisted Living in a Domestic Situation

In the case of the car mechanic there are a number of tools and objects proposed which will enable the variables of the passing task to be tested and evaluated across a wide range of the performance spectrum. Some of these form the core requirement but some others are optional suggestions which could help the investigation of the performance space. These are detailed in Table 2 below:

Table 2: Objects for the Assisted Living Scenario

Object	Preferred Human Grasp Point	Applicable Sub-Scenarios	Comments
Mug of tea / coffee	Handle (Essential)	Sitting Position	The mug is to be empty. An option is have the mug three-quarters full of cold liquid. This is not applied to the standing position due to the safety risks associated with an inform person holding a cup while walking with a stick.
Spectacles	By one arm of the spectacles, with the arms open (Non-essential)	Both	
Spectacle Case	Any	Both	
TV Remote control	Body of the controller with the IR transmitter facing away from the person (non-essential)	Both	From the point of view of fluent transfer this has very similar characteristics to a mobile phone, which is

Object	Preferred Human Grasp Point	Applicable Sub-Scenarios	Comments
			another common object used in ADL.
Book	Long edge of book (Non-essential)	Both	Paperback book is the preferred object. A hardback book is an optional addition
Drink tray	One edge of tray (Essential)	Both	The tray could be fitted with a handle for ease of handling by the robot. The handle could be either removable (desirable) or permanent. An option here is a food tray which would require two handed grasping (at each side) by the user.

4 Tasks to be Undertaken

This section describes the tasks that are to be undertaken during the trials within each scenario. The basic idea is simply that the object should be passed to the person by the robot and the robot should receive back an object from the person. These tasks are expanded in the sub-sections below for each scenario.

In the case of both the Car Mechanic and the Assisted Living scenarios the tasks specified for the trials are shown in Table 3. These tasks refer to the tasks to be performed by the robot. Trials will be constructed by combining several elements of these tasks. It is to be assumed that, where appropriate and within their capabilities, users will cooperate with the aims of the tasks.

Table 3: Tasks to be undertaken in both scenarios

Task	**Description**	**Comments**
Acquire object	The robot is to pick up each object from a tool rack or table at the start of each trial where the purpose is to hand an object to the person.	This is a desirable, but not essential, part of the trials specification. For the purposes of Coglaboration it is acceptable for the object to placed in the hand of the robot before the trial commences.
Offer object	The robot is to position the object within easy reaching distance of the user while still holding object	Does not apply to the lying under car sub-scenario
Pass object to static hand	The robot places the object in the users's open hand and then complies with the user in transferring the object	
Pass object to a moving hand	The robot tracks the user's moving hand, places the object in the user's open hand and then complies with the user in transferring the object with the hand still moving	The user needs to be made aware of the space envelope associated with the useful workspace of the robot
Drop object in open palm	The robot drops the object into the user's open palm, minimising the drop height	This is a desirable, but not essential, part of the trials specification. Only applies to the nut and bolt "small" objects
Take object from static hand	The robot grasps and offered object by the most appropriate grasp position and then complies with the user in transferring the object.	
Return object to its "home" location	The robot is to return the object to a tool rack or table at the end of a trial	This is a desirable but not essential part of the trials specification. However, it is assumed that most objects can be returned to a table.
Adapt motion strategies to observed human behaviour	The robot would adapt its motion pattern to better adapt to the behaviour of the human, either within trial or in subsequent trials.	This is a desirable but not essential part of the trials specification.
Follow a verbal command	Respond appropriately to a small set of verbal commands	Commands set to include the following commands: Stop

Task	Description	Comments
		Start Hurry up Slow down Release object Thank you (Used to signal performance success)
Follow a gestural command	Respond appropriately to a small set of hand/arm gestures	Command set to include the following: Stop Start Fetch (named object) Take object (from hand) Move faster Move slower Thank you (Used to signal performance success)

5 Performance Measures

In order to assess the performance of the system in undertaking the object transfer task a number of performance measures need to be taken. These performance measures need to be applied during all the trials across both scenarios to the extent that the trials allow. The measures presented here are just for completeness in terms of the experimental scenarios and should not be considered as final or definitive. The definitive performance measures will be presented in Deliverable 2.31.

Table 4 presents the performance measures currently considered as either necessary or desirable in order to assess the transfer process. In several cases further empirical study is necessary in order to decide the utility of the proposed measure.

Table 4: Proposed Performance Measures

Proposed Measure	Description	Performance Error	Comment
Total task duration	Time between passer initiating the task to when the receiver brings the object to the target position. These events are kinematically defined.	Task time too long (or possibly too fast)	This quantifies the overall performance
Reaching duration	Time between passer initiating the task and the receiver making contact with the object.	Task time too long (or possibly too fast)	Failure to find a target results in longer reaching duration
Contact duration	Duration during which both passer and receiver are in contact with the object. Ideally kinematically defined	Exchange taking too long / delayed gripping	Longer contact duration indicates possible failure to release grip and possibly dragging of the passer's hand
Grip force on object by passer	Grip force applied by passer before and after contact by receiver	Delayed grip force reduction by passer (delayed release)	
Grip force on object by receiver	Grip force applied by receiver before and after object release by passer	Dropping an object	Could be due to premature initiation of the transfer
Grip position / type applied to the object		Insecure grasp	Insecure grasp could be indicated by object stability, excessive grip force .
Grip force modulation	Velocity dependent force modulation	Inappropriate grip force modulation (grip force rate of change)	Grip force should be higher for a heavier object so that the total time to secure the grip in the hand remains the same
Approach velocity of passer	The mean and peak velocities of the passer approaching the receiver	Too fast or too slow	The velocity needs to be optimised to minimise the transfer time without causing surprise or distress to the user

Proposed Measure	Description	Performance Error	Comment
Velocity profile of object	The time of peak velocity and the number of peaks	A large number of peaks or an early peak velocity	Arresting movements (excessive movement correction) results in a number of velocity increases and decreases
Acceleration Profile	Mean and peak acceleration	Large number of acceleration reversals	
Jerk Profile	Mean jerk of the trajectory	Jerky motion	
Object handover position	Spatial location at which the object is passed	Handover position is outside the comfort zone of the user	Handover at either full stretch or close in to the body is likely to be a subjectively poor experience for the user and not result in a fluent exchange
Impact force at contact	Peak internal force at the contact point	Too high and impact force	
Motion and force produced by the robot	Motion of the hand and each digit throughout the trajectory together with the measured forces on the arm and hand		This is for diagnostic purposes and will be used to correlate with various events during the transfer task. Hence there is no specific performance error
Head / eye tracking	Head and eye movements of the passer and receiver.		This is for diagnostic purposes. The importance of this data still needs to be empirically evaluated. This will only be used in the human-human trials work.

One important aspect to note is that several of these measures imply a degree of instrumentation of the object being passed. The nature of this instrumentation and how it can be applied without materially affecting the handling properties of the object will be evaluated during the human-human trials in T2.3 and will be presented within Deliverable D2.31.

6 Conclusions

This report has presented the specification for two scenarios types and the associated tasks to be carried out and the objects to be used. This provides the baseline for the design of the experiments. It also provides a performance requirement against which the design of the robot system (including the hand and vision system) can proceed. This report will be used by following work to refine and develop the concepts set forth in this report in order to precisely define the trials regime. In particular the human-human trials in T2.3 will evaluate the desirability and practicality of the proposed tasks and objects while T6.1 will further refine the trials procedures and evaluation methods.