A New Perspective of Service Robots in Health Care Sector: Collective Organization Services

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Abstract - The ratio between the number of adults of working age and elderly is in decline. As a consequence, the health care public authorities of all the member states are starting to dramatically cut off supports. This trend will deteriorate in the years to come. Hence, no time should be wasted in optimizing health care resources. This need is at the origin of a new perspective of service robotics in the health care sector: the collective organization services.

1. INTRODUCTION
In the health care sector, collective organization services [16][17] are intended all the means to support caretaker professionals in their low-skill activities, such as transferring functions.

ROBOSOFT is leading a technology transfer initiative to provide transport assisted devices for caretakers. A robotic assisting device for transport functions, NESTOR, will be made available to hospital environments within the next two years.

As transport assisted device, NESTOR will be multifunctional and extremely convertible.

NESTOR will have different forms depending on the functionality to supply. NESTOR will be a self moving trolley, to carry on meal trays, samples, specimens, medicines, linen, medical equipment, etc. NESTOR will also be an electrical wheelchair to accompany people from site to site in hospitals.

Either as a trolley or as a chair, NESTOR will have the possibility to be operator accessed (“remotely supervised”) whenever desired. Moreover, depending on the situation, NESTOR navigation modality will be one of those:
• totally autonomous;
• tele-operated;
• entirely manual.

Switching from trolley to chair, as well as among navigation modalities will be for NESTOR absolutely easy taking less than a minute to execute.

Caretakers’ engagement in activities of transferring goods and/or people in health care centres, sums easily up to 25% of their working time [2]. This percentage is immediately overtaken in retiring homes. Indeed, the most missing need displayed by elderly people, even those in plain health, is right in mobility abilities.

NESTOR shall be adapted to supply the most of transferring commitments in health care environments.

Freeing precious resources, NESTOR will improve quality of care without inducing extra tax-load on the social community, nor caretakers unemployment.

II. NESTOR: A Technology Transfer Initiative to the Benefit of the Health Care Sector

To be such a multifunctional and extremely convertible transport assisted device, the technology components which are paramount to NESTOR are:
• the kit for Autonomous Navigation
• the Human Computer Interface

In the case of NESTOR, both those modules are technology components which have been thoroughly validated in other domains, and thus, are quite stable.

Namely, the kit of autonomous navigation is the one currently implemented onto commercially available automated scrubbing machines whose first prototype has been developed, by ROBOSOFT and other partners, under an European EUREKA project, CLEAN, on 1994. Fig. 1. shows a picture of the Autonomous Scrubbing Machine prototype developed under this project.

The module of the Human Computer Interface [9] has been developed within the context of the 3rd and 4th Framework Programme of the European Commission. Namely, it has been carried out under the actions aiming to exploit mobile robotics facilities for nuclear environments surveillance.

More recently, this Human Computer Interface has been tuned on several civilian activities, under a validation project financed by the European Commission, SMIS [10]. Fig.2 shows a picture of SMIS robot existing prototype.
Under SMIS project, the viability of tele-operated mobile robots to operate surveillance, in indoor and outdoor environments, has been extensively tested. Considering that in a teleoperated system, what guarantees success of the robot initiatives are the abilities of the remote operator to access and intervene on the robot, SMIS can certainly be regarded as an extended HCI validation opportunity.

CLEAN kit showed ability to cut off up to 30% of industrial cleaning costs and attain a quality of services of 100%.

SMIS module has opened new frontiers to mobile interactive surveillance sectors.

NESTOR, resulting from the successful technology transfer of those two modules, will:
- inherit CLEAN and SMIS associated benefits;
- multiply their effects in a new field of applications, i.e. the health care sector.

III. NESTOR at Present Technical Feasibility
The technical feasibility of NESTOR is totally founded on that of its two technology components:
- the autonomous navigation (CLEAN) kit
- the Human Computer Interface (SMIS) module

Considering the major frailty of people NESTOR shall meet, mostly, patients, elderly and disabled, the CLEAN kit and the SMIS module might be complemented with extra features aiming at making the system/humans conviviality safer and more comfortable at the same time.

Currently Available CLEAN Kit Features are:
i) trackless navigation;
ii) detection of objects and/or people (i.e. « obstacles ») on its way;
iii) stopping in front of obstacles;

CLEAN kit does not require modifications in the environment. For absolute localization issues and/or for communication links only small reflectors and/or transmitters/receivers might be placed on walls.

Currently available SMIS module features are:
1. supervision of the machine overall status whatever it be, moving or at rest;
2. intervention on the machine site while sitting in a remote control room. For instance, give it commands to go somewhere, steer it (as a « tele-operated » device) and/or even resume it when stuck.

IV. NESTOR Expected Features

Autonomous navigation
NESTOR onboard capabilities will comprehend:
- global positioning facilities (essentially, software and hardware means to retrieve \((x, y, \theta)\) Cartesian and angular
coordinates of the mobile platform with respect to a fixed reference frame)
- **path planning for global navigation** facility (essentially software means to define a « optimal » trajectory path between two initial and final positions, respectively \((x_i, y_i, \theta_i)\) and \((x_f, y_f, \theta_f)\))

**NESTOR** is expected to operate in structurally known environments. Therefore, to fasten autonomous navigation procedures, this information shall be used. CAD models, and/or other facilities to provide a-priori knowledge of the environment, will be part of the onboard robot software facilities.

For **global navigation** issues (i.e., to move from point to point in a given (known) environment) the NESTOR will be endowed with:
- digital map of the environment
- accurate global positioning means
- trajectory planning modules
- dynamical control modules [15][14]

For **local navigation** issues (i.e., to cope with abrupt changes of the environments, normally, obstacles on the way to the final goal), NESTOR shall have abilities in:
- detecting the obstacles;
- finding an optimal strategy to surround obstacles (i.e. insert intermediate goals \((x(i), y(i), \theta(i))\), \(i = 1, 2, \ldots, n\) on its path towards the final goal);
- surrounding obstacles;
- resuming the global navigation towards the final goal once the obstacle avoidance strategy is over.

**NESTOR** shall be capable to switch from one navigation capability to the other with flexibility and rapidly.

Moreover, NESTOR will be able of:
- using voice signals to make people aware of its being on their way;
- coping with safety distance (replicating the human behavior « I saw you and hence give you more space »);
- make visible and easy-of-use stop switches on board, in case of any emergency occurrence;

**Human Computer Interface**

The Human Computer Interface, which is currently available only on the operator workstation, shall be made available into two distinct components:
1. the **interface at the operator's console**;
2. the **interface onboard**.

The **Console Human Computer Interface** must incorporate functions as:
- **navigation**, allowing the operator to steer the platform, either by indicating the goal function (**autonomous navigation mode**) or by direct steering (**tele-operated mode**);
- **monitoring** (i.e., showing the operator the current status of the system, e.g., where it is the vehicle, the status of execution of the current task, sensor information, etc.);
- **video conferencing** (i.e., voice and video feedback especially when a person uses the NESTOR platform as an electrical chair).

The **Onboard Human Computer Interface** will be mainly composed of:
- a **LCD display with a keyboard** for simple interaction with caretakers;
- a **video monitor and loudspeaker** for video conferencing with the caretakers at the console.

The onboard HCI is to:
- broad the means to give NESTOR commands;
- enable the access of same useful databases stored in an elsewhere computer (such as patients records, diets, etc.);
- increase comfort in using the platform by the users (such as allowing live voice talks between the NESTOR platform and the remote control position when it is used as a self-moving chair).

**V NESTOR Market Potential. Main Issues.**

NESTOR market potential comprises all the medium/large size centres supplying health and social care services. Those centres existing all over the world, the market potential of NESTOR is worldwide.

The data listed in Table 1 provide a meaningful idea of what is the current NESTOR market potential in Europe. These are data of the national statistical institutes of Denmark, Germany and Spain.

Denmark, Germany and Spain have been selected as the NESTOR validation sites, as they are the countries, amongst the most representative from north, centre and south Europe, in what concerns ongoing economies and health care social model. The non-homogeneity of the figures listed below depends on the difference in the data sources.

<table>
<thead>
<tr>
<th>N. Hospitals</th>
<th>Denmark Danmarks Statistik</th>
<th>Germany Federal Statistics</th>
<th>Spain Instituto Nacional de Estadistien</th>
</tr>
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<tbody>
<tr>
<td>116 on 1980</td>
<td>2354 on 1993</td>
<td>790 on 1993</td>
<td></td>
</tr>
<tr>
<td>102 on 1985</td>
<td>2337 on 1994</td>
<td></td>
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</tr>
<tr>
<td>90 on 1990</td>
<td>2325 on 1995</td>
<td></td>
<td></td>
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<tr>
<td>84 on 1995</td>
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</tbody>
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Table 1: Number of (public and private) Hospitals in Denmark, Germany and Spain.
Customers of NESTOR are partitioned into a threefold structure, as shown in Table 2:

<table>
<thead>
<tr>
<th>GROUPS</th>
<th>NESTOR</th>
</tr>
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<tbody>
<tr>
<td>End Users</td>
<td>Health Care Staff</td>
</tr>
<tr>
<td>Purchasing</td>
<td>Decision</td>
</tr>
<tr>
<td>Makers</td>
<td>Health Care Centres</td>
</tr>
<tr>
<td>Payers</td>
<td>Public/Private Funds</td>
</tr>
</tbody>
</table>

At which speed the market potential of NESTOR is expected to grow up is a quite complex question.

Today, there exists only a single commercial product, which, as NESTOR, affords the perspective of collective organization services in health care environments. It is the HelpMate platform developed by HelpMate Robotics Inc. in Danbury (CN).

Data from the HelpMate Robotics Inc. itself tell that NESTOR addresses a market with a yearly mean growing rate of 10% in USA/Canada and a potential of tenths of platforms only in the European capitals today.

As any product accessing a market served by a single commercial product, NESTOR shall induce amelioration of the competitor system and encourage other actors to access the market.

Both are favorable reactions. In fact, they shall:
- increase opportunities for money saving in the health care sector;
- foster better quality technology applications;
- reduce the time-to-market for other NESTOR-like and complementary products.

VI Conclusions
Timing to optimize transport activities in hospital environments is particularly suited as Europe is experiencing a serious emergency. Indeed, Europe is ageing so rapidly that in 2025 the elderly population is expected to control roughly 70% of the money (disposable income + fixed assets) [1].

This scenario makes the optimization of health care resources a truly obligation, today.

NESTOR, relieving caretakers of unskilled activities, as pushing trolleys along corridors, will free precious resources. As a consequence, health care staff will have more time available for patients in hospitals, elderly in retiring homes, handicapped in rehabilitation centres. Hence, NESTOR will significantly contribute to improve quality of care.

VII REFERENCES