TECHNICAL AND SCIENTIFICAL REPORT, STAGE 3 (2020)

PROJECT 3

The intelligent control, of the of the Complex Autonomous System -SAC-ARP Personal Robotic Assistant and Complex Autonomous System -SAC-VAM Multidirectional Autonomous Vehicle integrated in medical-social assistance and line service technologies flexible manufacturing of precision, laboratory (mechatronics lines) and industrial, with advanced techniques and navigation based on high-performance sensors and visual servoing systems

STAGE 3 (2020)

The testing of the control and navigation structures of the complex autonomous systems, SAC-ARP and SAC-VAM, in laboratory regime; Integration of SAC-ARP in intra / extra hospital personal assistance technologies; Integration of complex autonomous systems SAC-ARP and SAC-VAM in hybrid technologies serving flexible precision, laboratory, mechatronics, A / D, Hera & Horstmann manufacturing lines; Integration of complex autonomous systems SAC-ARP and SAC-VAM in hybrid control technologies to serve flexible precision manufacturing, laboratory, mechatronics lines P / R, Festo MPS200

The researches of Stage 3 meet the research objectives related to Activities 3.9, 3.10, 3.11, 3.12 of the implementation plan of the complex project, and ultimately led to the implementation and laboratory testing of real-time management of an Integrated System for Flexible Manufacturing (SIFF), served by complex autonomous systems, SAC-ARP and SAC-VAM. In this stage, the hardware structure of the production system was finalized, ie the existing system was completed, intended for flow manufacturing, with a flexible disassembly cell equipped with ABB industrial manipulator and the management structure was realized and implemented in real time to ensure capability. of processing / reprocessing of the manufacturing line using the complex autonomous systems SAC-ARP and SAC-VAM, which equipped with driving algorithms that give autonomy, can be used in intra and extra hospital applications.

RESULTS OBTAINED

-Mobile visual servoing system placed on the manipulators that equip SAC-ARP and SC-VAM;

- SAC-ARP and SAC-VAM integrated in the technology of personal intra / extra hospital assistance:

-SAC-VAM tested in rescue actions in rough terrain;

-SAC-ARP and SAC-VAM integrated in a hybrid service technology on precision manufacturing lines f, A / D and P / R, in laboratory mode;

- Results of laboratory testing of the management of flexible manufacturing lines integrated in hybrid precision flexible manufacturing technologies, assisted by SAC-ARP and SAC-VAM

Act 3.9 -Testing the management and navigation structures of the complex autonomous systems, SAC-ARP and SAC-VAM, in laboratory regime; -Dissemination of results

The structures from Stage2-2019 for the Pioneer 3Dx and PeopleBot robots involved in taking over the parts recovered from the disassembly station were tested. For navigation, obstacle avoidance and time travel algorithms have been validated, in order to ensure synchronization with the production line and / or with the requirements imposed by the hospital user. The management and navigation structures of the complex autonomous systems, SAC-ARP and SAC-VAM, were tested in a laboratory regime. SAC-ARP systems have been equipped with navigation systems for bypassing obstacles and with trajectory tracking algorithms for time travel. These management structures have been integrated into in-hospital and out-of-hospital personal care technologies, hybrid technologies serving flexible precision manufacturing lines, laboratory, mechatronics, A / D, Hera & Horstmann, and hybrid technology serving lines. Flexible manufacturing, laboratory, mechatronics, P / R, Festo MPS200.

Figure 1

SAC-ARP considered at this stage is the assembly consisting of the mobile robot (WMR) (PeopleBot), robot arm (Cyton) and camera (Logitech). The video camera is placed on the last section of the manipulator (next to the final effector). WMR has the task of moving the robotic manipulator with component P4-R from S0 to the storage of workstation S4.

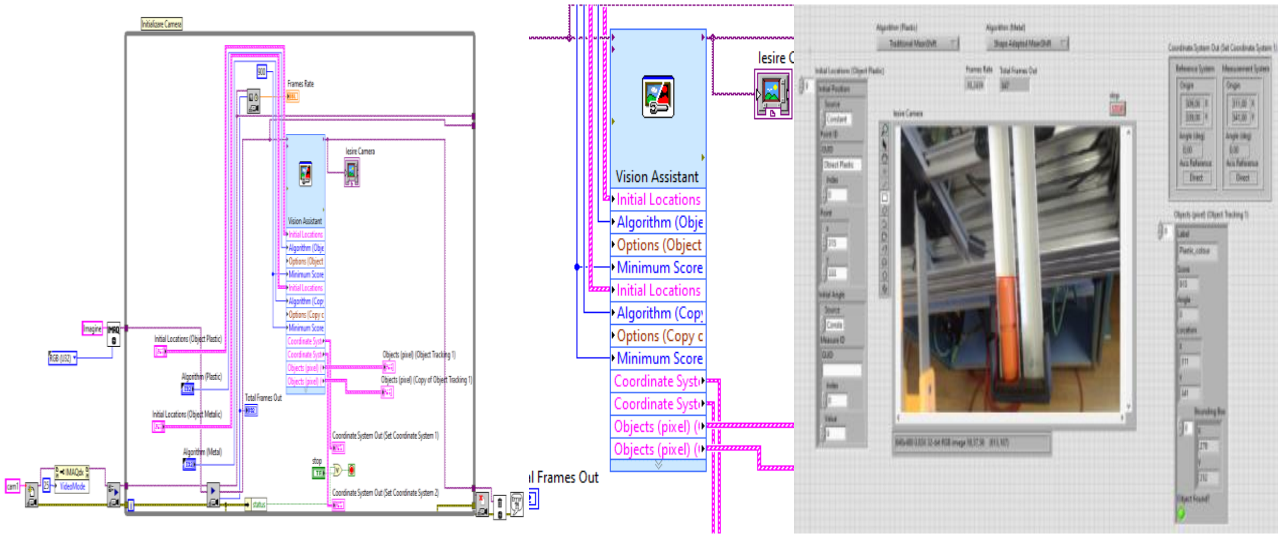

Figure 2

The movement of the WMR is controlled by a trajectory tracking algorithm: this means that the WMR moves in a desired path in a given time, without exceeding the restrictions (for example, the speed / acceleration limit). To retrieve the P4-R component from the S0 workstation, an algorithm is proposed to detect the exact position of the component, using LabView (Fig.1). It is still used to control the final effector of the manipulator, based on the data purchased from the camcorder. This is how the mobile visual servoing algorithm works.

This algorithm is useful because the WMR with the robot arm is not always in the same position (at the same point) in front of the disassembly workstation (S0). This is due to model uncertainties, WMR slips or possible surface unevenness.

Act 3.10 - Integration of SAC-ARP and SAC-VAM in intra / extra hospital personal assistance technologies; - Dissemination of results

For the integration of SAC_ARP and SAC-VAM in in-hospital and extra-hospital assistance technologies, navigation algorithms have been improved, bypassing fixed and mobile obstacles, developed in Stage 2 and algorithms for moving through narrow spaces (doors, or narrow color). These were complemented with object retrieval algorithms using algorithms based on visual servoing, algorithms used in complex systems for serving flexible manufacturing lines. Object retrieval algorithms are strictly necessary for the development of personal assistance techniques.

The visual servoing system of SAC-ARP or SAC-VAM

The main steps of the control algorithm are:

1) extract useful visual information to calculate the characteristics of the object;

2) uses this information as inputs for the control loop (knowing that the error is calculated between the current visual characteristics and the desired values of those characteristics);

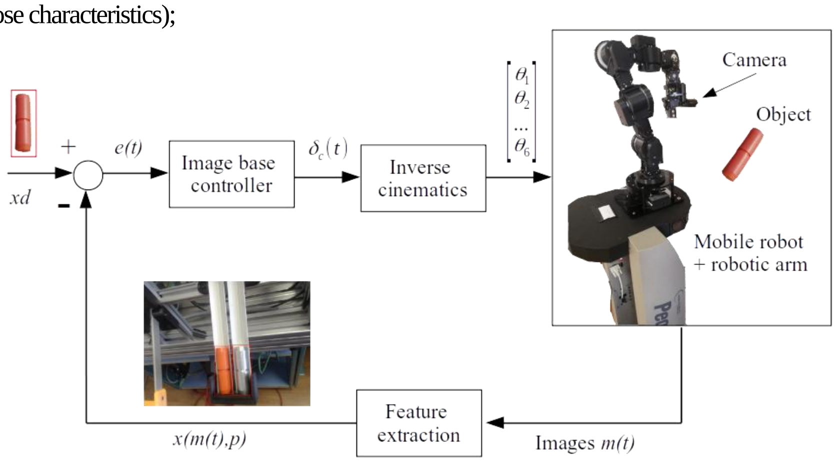

Figure 3

3) the controls (outputs) (for example, the speed of the robot arm) are calculated to reduce the error, as seen in Fig.3 in which the block diagram of the driving structure based on visual servoing is represented.

The real-time implementation aims to identify the objects and transport them to the corresponding points (each of the 4 objects has an associated destination point). To accomplish this task, the SAC-ARP must identify and retrieve the object from station S0 (this is the control algorithm based on visual servoing) and deliver it to the destination station by traversing a desired path. Navigation management based on Trajectory Tracking must ensure not only the planning of the road on which the trip is made (as can be seen in the "path" desired in Fig. 4 of the extended report), but also the speed profiles (time dimension - see Fig. 5).). Fig.5 and Fig.6 graphically show the results obtained after real-time implementation on SAC-ARP (consisting of WMR PeopleBot and Kyton manipulator equipped with visual servoing system). The results of the real-time experiment are presented in Fig.4, where the path followed by SAC-ARP is displayed. The navigation management controller is used to solve the path tracking problem with minimal errors. Fig.5 and Fig.6 graphically show the experimental results of the "sliding-mode" driving algorithm used for SAC-ARP in terms of error dynamics and linear and angular velocities. It is very easy to see how the designed controller can accurately follow the trajectory of SAC-ARP or SAC-VAM. The solution to the minimum time navigation problem (Trajectory Tracking) is based on the design of a "Sliding Mode" type controller.

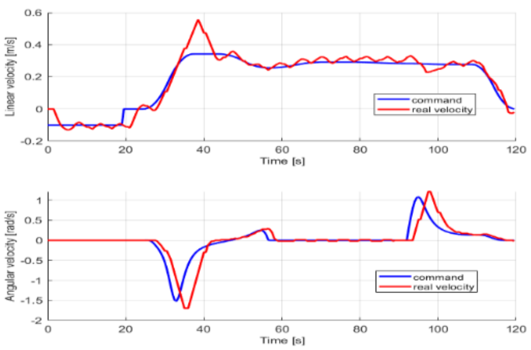

Figure 5

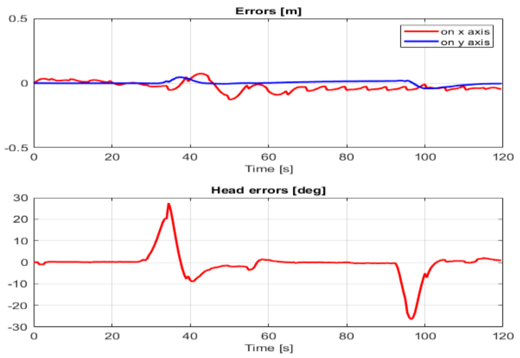

Figure 6

The results of the real-time experiment are presented in Fig.4, where the path followed by SAC-ARP is displayed. (http://cidsacteh.ugal.ro/documente/Raport%20Proiect%20P3%202020.pdf)

The navigation controller is used to solve the path tracking problem with minimal errors. Fig.5 and Fig.6 graphically show the experimental results of the "sliding-mode" driving algorithm used for SAC-ARP in terms of error dynamics and linear and angular velocities. It is very easy to see how the designed controller can accurately follow the trajectory of SAC-ARP or SAC-VAM. The solution to the minimum time navigation problem (Trajectory Tracking) is based on the design of a "Sliding Mode" type controller.

Act 3.11 -Integration of the complex autonomous systems SAC-ARP and SAC-VAM in hybrid technologies serving flexible precision, laboratory, mechatronics, A / D, Hera & Horstmann manufacturing lines

Act 3.12 Integration of the complex autonomous systems SAC_ARP and SAC VAM in the technologies of serving flexible precision manufacturing lines, laboratory, mechatronics, P / R, Festo MPS200

One of the main problems with flexible manufacturing or assembly systems is productivity. There are various ways to address this issue, including ordering tasks, reactively assigning tasks, or attempting to reuse / reprocess nonconforming parts.

At this stage, a real-time management application was developed to ensure the ability to reuse / reprocess nonconforming parts in a flexible Mechatronics (FMML) manufacturing line as can be seen in Fig.7. The flexible manufacturing line, considered for the application, is a HERA & Horstmann Assembly Mechatronics (AML) line. In this stage, the real-time control application of SAC-ARP and SAC_VAM of the mobile wheeled robot (WMR) equipped with a 7DOF manipulator that has a mobile visual servoing system (VSS) was developed. VSS uses the Eye-in architecture. -Hand to perform tasks of taking over and transferring objects with a priori unknown positions. Autonomous robotic systems use visual servoing systems to increase their autonomy capabilities. Mobile robots that integrate visual servoing control to facilitate the grasping and handling of objects on which transfer them autonomously to the destination, are the main topics of the stage. Detailed results can be found in the extended report (http://cidsacteh.ugal.ro/documente/Raport%20Proiect%20P3%202020.pdf).

The structure of the complex system is presented in the figure below: In the flexible assembly / disassembly production system there are several tasks to be performed. The initial Mechatronic assembly / disassembly line (A / DML) consists of 4 workstations WS1, WS2, WS3 and WS4 where the assembly between the corresponding part and the subassembly is processed. For the disassembly load, add a workstation, called "Flexible Cell" in Figure 8, or S0, which contains an ABB industrial manipulator, which performs the disassembly operation. To perform reprocessing, the parts resulting in S0 must be identified and then transported to the appropriate warehouse of the assembly workstation. SAC-ARP or SAC_VAM (a mobile wheeled robot (WMR) equipped with a manipulator) is used for this task. The task of WMR is to deliver the part from S0 to the appropriate warehouse of the assembly workstation in minimum time and bypassing any obstacle. This task is performed using a trajectory tracking algorithm. The task of SAC-ARP or SAC_VAM is to identify the part (with unknown position) and then deposit it in the assembly of the assembly workstation corresponding to the operation in which it is involved. For this task SAC-ARP or SAC_VAM uses a driving application based on visual servoing. The real time implementation of this application is using LabView.

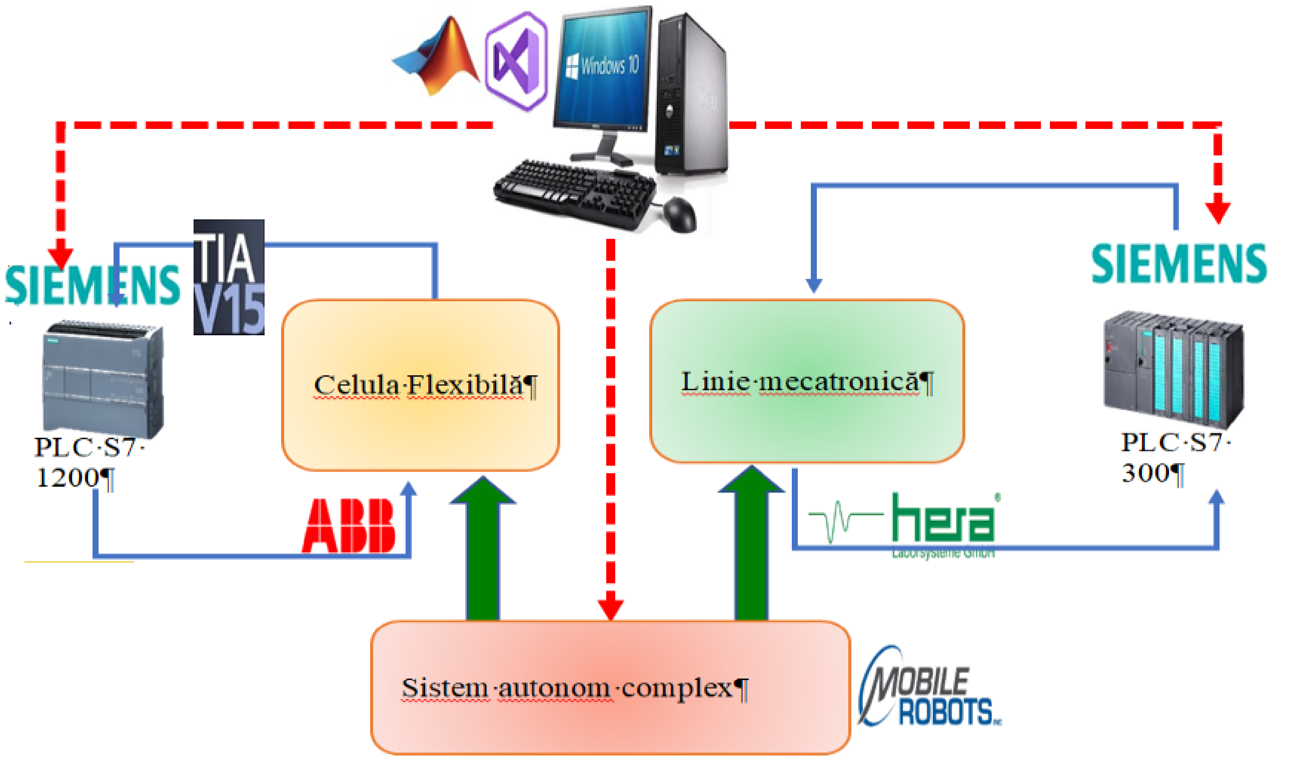

Figure 7

The control of this system means the integration of the 3 subsystems:

- Flexible cell: multifunctional flexible cell (HR) equipped with IRB ABB 6-DOF. Programming the ABB Robotic Manipulator using RobotStudio and the Siemens S71200 PLC
- Mechatronics line: assembly / disassembly control is done strictly through the "Central System" - Siemens S71200 PLC and HMI operator panel
- Complex autonomous system (SAC-ARP or SAC-VAM): RM positioning: trajectory-tracking and sliding-mode control (TTSMC) + Pickup and release of the part: VSS technology "eye-in-hand.

An HMI interface has been designed to drive this system and synchronize operations. Depending on the option chosen in the HMI, namely Product Type 1 or Product Type 2, the location where the product is assembled and its move / transport to the final storage point is determined.

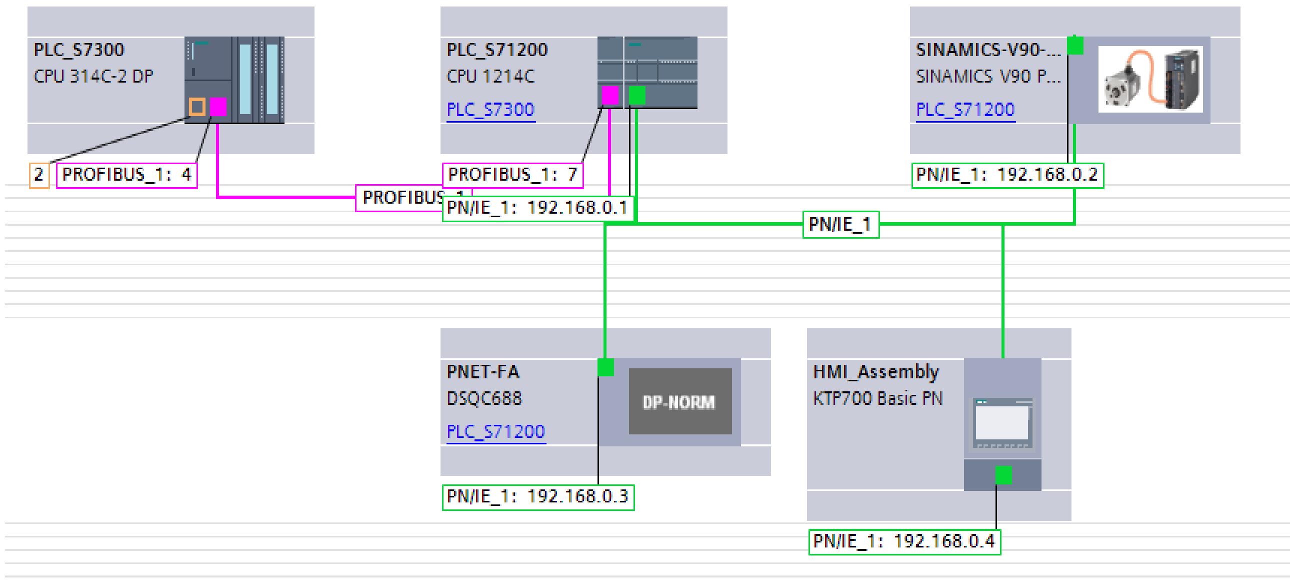

Figure 8

The architecture of the central line management system is represented in the structure diagram below: Central automation system designed. HMI interface

Figure 9

Disemination of the results

-*Improved Image Processing Algorithm for Quality Test on a Flexible Manufacturing Mechatronic Line*, Marius-Adrian Păun, Eugenia Minca, Adrian Filipescu, Octavian Gabriel DUCA, Adriana Filipescu, 24rd International Conference on System Theory, Control and Computing (ICSTCC), Sinaia, Romania during October 8-10, **2020,** *(in curs de indexare)*

- *Optimal control of a flexible assembly technology on a mechatronics line with integrated industrial robotic manipulators*, Octavian Duca, Eugenia Minca , Adrian Filipescu , Henri-George Coanda , Florin Dragomir , Adriana Filipescu, Journal: Sensors, Manuscript ID: SENSORS, 981733, **2020**, pg.921-926, 978-1-7281-9809-5/20/$31.00 ©2020 IEEE

-*Manufacturing Technology on a Mechatronics Line Assisted by Autonomous Robotic Systems, Robotic Manipulators and Visual Servoing Systems*, Adrian Filipescu, Eugenia Mincă, Adriana Filipescu, Henri-George Coandă, Journal name: Actuators, Manuscript ID: actuators-991918, (*in evaluare*), **2020**

- *Hybrid Control Application Using Mobile Visual Servoing for Flexible Manufacturing Mechatronics Line*, Daniela Cernega, Razvan Solea, 24rd International Conference on System Theory, Control and Computing (ICSTCC), Sinaia, Romania during October 8-10, 2020, pp 636-641 *(in curs de indexare)*.