

## A Simple and Effective Emulation Tool Interface Development for Tricept Application

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### ABSTRACT

Simulation tools play a very important role in robot applications, such as in production planning, work-cell layout planning, feasibility study etc. Among the commercially available robot simulation tools, most of them are expensive and need a well-trained person to run the software. When robots are used in mass production, the cycle time for the process or some NC blocks is often critical and simulation software have difficulties in the real cycle time due to the fact that the velocity profile, jerk limitation of the machine are not the same as the simulation environment, especially for the PKM machine. An emulation tool can help solve this problem by running the NC program on the real control without running the machine physically connected, the cycle time can be monitored and the machine movement can be shown in 3D on the screen. This paper presents a simple and effective interface development for Sinumerik 840D control for PKM 5/6 Axis machine centre Tricept™ and 3D simulation tools Easy-Rob™ IGRIP™. With this interface the Tricept™ can run with real control visually on the computer. The possible applications for the tool are also discussed.

**Keywords** Robot simulation, robot emulation, real-time simulation..

### 1 INTRODUCTION

Simulation tools have been widely used in robotics applications, such as in production planning, workcell layout planning and cycle time estimation. With the help of simulation tools, the whole mechanical system can be modeled and simulated visually in 3D. The collision between the robot, tool and the environment bodies can be checked during the simulation. There are many commercial robot simulation software packages available on the market, such as IGRIP™, ROBOTCAD, ADAMS. They are powerful and also very expensive and need well-trained persons to run the software. For the robot end users this is a big budget. On the output side some of the robot simulations offer an interface to robot control for real robot simulation [1]. These robot control interfaces are control specific.

With the development of Parallel Kinematics Manipulator (PKM) more and more PKMs are used as both robot and NC machine. This is due to the fact that PKM has the characters of high static and dynamic stiffness, high position accuracy and high flexibility. As a robot off-line program can be widely used in PKM robot application such as welding, assembly or drilling. It can also be used as an NC machine centre performing 5-axis milling and drilling. The Tricept is one of the most successful PKM machine centres on the market.

In the NC-machine application, most of the simulation tools come with the CAM system. They can simulate 5-axis machining in 3D only with the spindle orientation but the system does not have the information of the machine kinematics. For the conventional NC machine it is enough. For PKM, the TCP and orientation generated by the CAM may not be accessible by the machine. When the machining process becomes more and more complex, such as where multi-spindles may be installed on the end actuator, then the 5 axis CAM simulation can not meet the demand. Tricept can even offer 6-axis robot functionality to meet complex applications. General CAM simulation can not meet such application.

Tricept use Sinumerik 840D as its NC control. Sinumerik 840D is an open architecture NC control system. With the special compiler cycle installed, it can be used for PKM applications. In the control system MMC, it also has an integrated simulation tool, however, it only offers a very limited 3-axis simple tool path simulation [2]. For PKM applications the simulation must offer the whole PKM mechanical simulation, the simulation should be able to detect the soft limitation of the machine axis and singularity, because Cartesian position can not reflect the machine axis position.

Easy-Rob is a newly available simple, powerful and affordable 3D robot simulation. It offers different modules to scale the system. The Tricept modelled in Easy-Rob is shown as in Figure 1

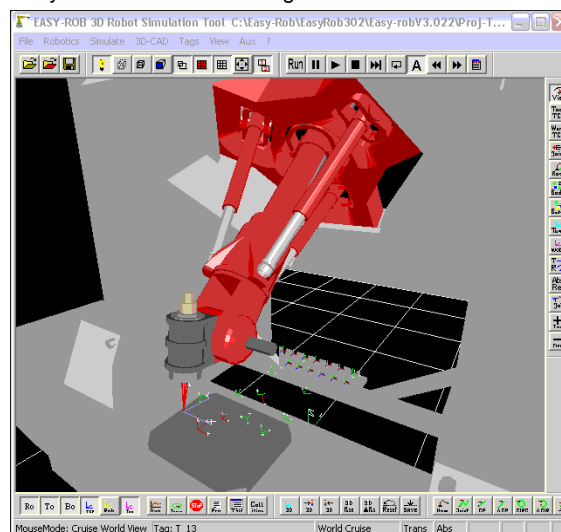


Figure 1 Tricept in EasyRob

In this paper we developed a simple and effective interface (NCLink) for the Easy-Rob simulation software and the Siemens SINUMERIK 840D control. The interface can also display the NC information online. This will make the simulation tool an emulation tool and can be used as an NC program verification emulator for production monitoring. When the Easy-Rob and the interface are installed on the MMC, Easy-Rob can be used as an integrated simulation/emulation tool for the Siemens SINUMERIK 840D control. The interface is programmed in VC++.

## 2 NCLINK INTERFACE DEVELOPMENT

The requirements for the NCLink interface are defined as follows.

Collect data from Siemens SINUMERIK 840D:

- All current joint values (machine axis values)
- Current TCP value and tool orientation in Cartesian coordinate system.
- Current alarm information of the Siemens SINUMERIK 840D.
- Current NC block information, Tool Number, cutter edge number, M code, G code, feed rate (set value, actual value and override), spindle value (set value, actual value and override value)
- Current NC state like operation mode, transformation on/off.
- Customer defined cycle timers, which can be started and stopped from NC program.

Simple task on SINUMERIK 840D:

- Copy NC program from host computer (PC) to the MMC and load in NC.
- Unload NC program from NC.
- Start/stop NC program from (only for the test mode)
- Jog machine in machine axes in transformation off mode and jog machine is Cartesian CS when transformation is on (only for test mode)

Pass data to the 3D simulator:

- Send all necessary data to the 3D simulation tools (Easy-Rob or IGRIP) whenever data has been changed and request a windows update.

### 2.1 Communication with Siemens 840D [3]

In order to get the real time information from the NC control side, the interface must be able hook to the Siemens SINUMERIK 840D during the operation, collect the necessary information and pass it to the simulation tool via the network in real time.

Siemens SINUMERIK 840D is an open architecture system and Siemens also provides different development tools for different applications, like compiler cycle OEM package for NC development MMC OEM package for MMC development, SinCom for IT solution. Due to the fact that these applications have relatively "heavy" traffic demand and have a lot of data which not necessary for this specific application and the fact that the MMC run on a Windows 95/NT operation system and all the communications between MMC and NC is based on the DDE connection application, we can also write a "light" DDE application and get the

information we need. In the MMC there is a NCDDE server. It is the interface between the MMC and SINUMERIK 840D. The MMC uses this interface to access all data of the NC, the PLC and the drives. The NCDDE server provides the following three different services for the developers of applications:

- Variable service: Accessing NC, PLC and drive data.
- Domain service: Copy files from MMC to NCK and vice versa.
- PI service: Start program-invocation services of the NC.

Form the requirement of our interface we need use all of the three services of the NCDDE server.

Dynamic Data Exchange (DDE) is a Windows operation system supported service and can be used to transfer data from one Windows process to another. NCDDE server provides three DDE link modes:

- Request: the client request only once
- Warnlink: the server informs the client when data have changed. Then the client can access this data item.
- Hotlink: if the data has changed, the server automatically supplies the current data value to the client.
- Execute: The client instructs the server to execute a command.

As described above, in order to get the online data from the SINUMERIK 840D NC Hotlink mode is needed. To perform an NC program transfer Execute mode is needed.

When the NCLink interface and the simulator are used as integrated simulator the configuration is shown in Figure 2.

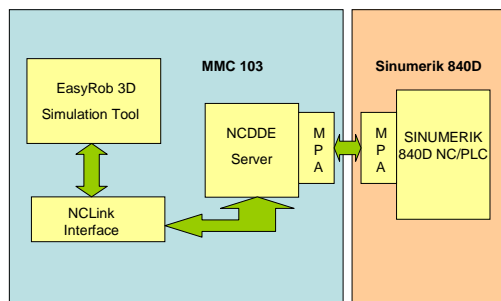


Figure 2 integrated simulator configuration

When the interface is installed on a PC which is on the same network as the MMC a extra DDE server, NETDDE, is needed to start before the connection can be established. NETDDE is provided by the Windows operation system. NETDDE post the NCDDE on to the network. The configuration is shown in Figure 3.

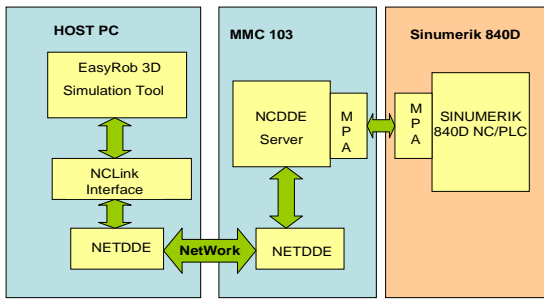


Figure 3 network configuration

NCLink also provides a simple Graphic User Interface (GUI) and lets users setup the location of Siemens SINUMERIK 840D controller, the computer which runs the simulation tool Easy-Rob or IGRIP on the Network, the port number which is used to access data. For test/debug purposes a small simulated control panel is provided and can be used to perform simple control tasks to Siemens SINUMERIK 840D. NCLink acts as a “mini” MMC.

2.2 Communication with simulation tool

After the data have been collected, the necessary data need be to be sent to the simulation tool. Many 3D simulation tools provide an interface to other applications. Easy-Rob provides a function called “Remote control” with TCP sockets. It allows the user to interchange data with other programs. The system provides the Application Program Interface (API) as a Dynamic Link Library (DLL) “err\_remote.dll”.

The functionalities are shown in Figure 4 [4]

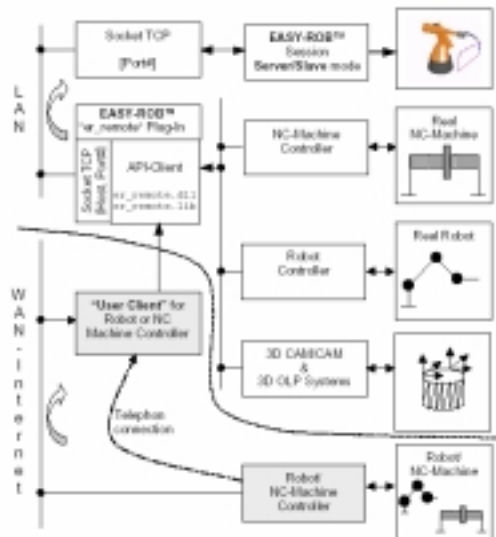


Figure 4 Easy-Rob Remote function overview

In this application Easy-Rob acts as a server session. This means that Easy-Rob must be started first then turn on the remote function and wait for a connection from the client. After the connection has been established, NCLink can continually send data to Easy-Rob.

As shown in Figure 4. Easy-Rob use a TCP/IP socket. The link can also be established via local network and Internet.

The data sent to Easy-Rob is the data package that consists of only joint values and the operation ID, the data size is very small. This lets the Easy-Rob be used even on a relatively slow net connections. With these joint values and operation ID Easy-Rob is able to update the Tricept status.

A similar interface is also developed for IGRIP robot simulation.

3 APPLICATION EXAMPLES

This emulation tool can be used in different situations. Some potential applications are explained as follows:

3.1 Production monitoring

The configuration is as shown in Figure 5. In some applications several Tricept machines are used on a production line or even in a station, each Tricept performs different tasks. With the help of NCLink, all Tricept position information and other important status information can be collected and displayed on the central computer on the net with simulation tools like Easy-Rob or IGRIP. To check a specific Tricept, the user selects the window and zooms in /out of the view to check the detail of the TCP or the fixture in 3D. As shown in Figure 5 Tricept\_1 ..Tricept\_3 can be displayed on PC-2 windows and Tricept\_1 can also be displayed on PC-1 windows via network.

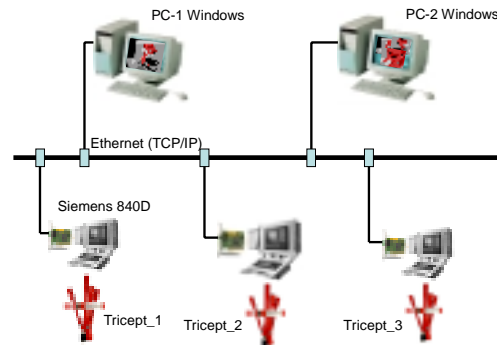


Figure 5 Production monitoring

3.2 Production planning

With the traditional robot or machine simulation, the process cycle can be estimated. However the real cycle time is difficult to estimate accurately. This is due to the fact that the control has the different system parameters than the simulation motion plan parameters. The algorithms for motion plan are also different. With the help of this real-time simulation the cycle time can be estimated accurately.

3.3 Education

The emulation tool can also be used as an operator training tool. Tricept as PKM used as machine centre with 5/6 axis functionality. This tool provides the ideal training tool for the education.

Mistakes are often made by new operators when operating a new type of machine especially for those who have never operated a Tricept. By setting the Siemens SINUMERIK 840D NC in test mode, without

running the Tricept physically, the operator can load NC program and run them in different operation modes from the MMC 103 control panel. The Tricept can be displayed on a PC or MMC 103 window. This will eliminate the risk of damage to the Tricept by a wrong operation.

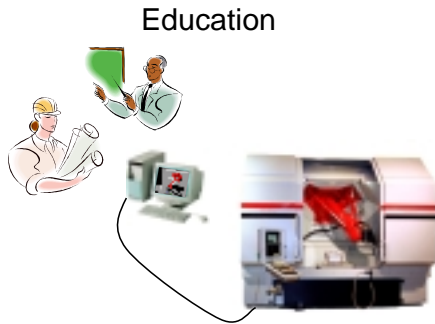


Figure 6 Operator training tool

### 3.4 Research and development

When new kinematics are introduced such as from 5-axis to 6-axis machining, new types of tools are used or new type PKM structures are developed. The control algorithm can be implemented by compiler cycle and tested on the Siemens SINUMERIK 840D. The behaviour can be displayed by the emulation tool. After all functions work properly, the real machine can be built and tested. As shown in Figure 7.

### 3.5 Remote diagnostics tool

The NCLink can be used as simple remote diagnostics tool for Siemens SINUMERIK 840D. With NCLink it can read NC or PLC data, check status of NC and write data back to NC or PLC. As shown in Figure 8.

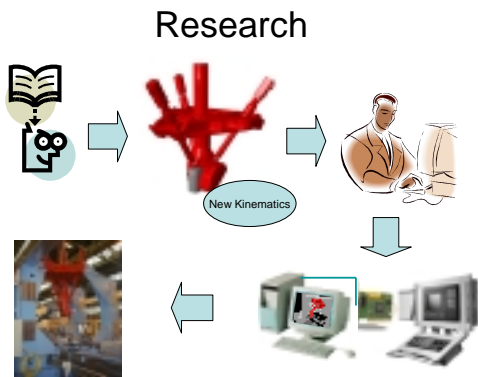


Figure 7 Research and development tool

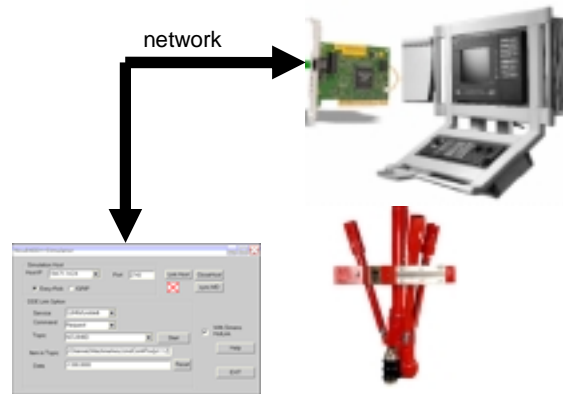


Figure 8 mini remote diagnostic tool

## 4 CONCLUSION

The emulation tool interface proposed is simple and effective. It can be used in either integrated mode in MMC or separated mode in a separate PC via network. It can display the Tricept in real time. The size communication data is small and can be used even on the relative slow network with full 3D emulation functions.

## 5 REFERENCES

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