Review of STEP-NC System Controlled by Android Platform Through Wifi

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ABSTRACT
STEP (STandard for the Exchange of Product model data, ISO 10303) data for numerical control (NC), or the new standard STEP-NC (ISO 14649), is intended to provide full product and process data interoperability between computer-aided manufacturing systems and machine tool controllers. Wireless networks have been widely developed compared to wired networks, and the wireless communication removes the restriction of wired connections. One of successful wireless networks architecture is WiFi (wireless fidelity) and it is very popular in providing different data services. Integrated WiFi network is a great potential for the future due to the high data transport capacity of WiFi. Google’s Android platform is a widely anticipated open source operating system for mobile phones and the idea to integrate with NC machine through WiFi will be a contribution for manufacturing industries. This research focuses to explore the theories and techniques behind procedure of STEP-NC system controlled by android platform through WiFi. The developed application controller enables the machine tool to be controlled based on wireless communication, android platform and STEP-NC data generated from CAD/CAM systems.

Keywords: STEP-NC; turn/mill; Wifi; Android; framework.

1. INTRODUCTION

Today’s CAD/NC process chains have a major lack. They require a number of data conversions. These conversions are time-consuming, often irreversible and afflicted with information loss. The major bottleneck of this process chain is at its end. Actual, NCs mostly require ISO 6983 as input format. This data format was suited in the beginning of computerized machining when only simple data formats were processable. But as a consequence of the progresses in production engineering, the higher complexity of machine tools and proceeding information integration within and between facilities as well as modern forms of labor organization the limited, machine-dependant data format of ISO 6983 is not appropriate anymore since it necessitates a number of post processors and inhibits the feedback of worker know-how.

STEP-NC is the backbone of the counterpart scenario for CAD/NC process chains. Since it allows direct use of CAD data and will form the direct input format for the NC, no conversion operations are necessary. All components of the process chain are working on the same data format enabling a closed-loop process chain. Its object-oriented information model eases the development of graphical NC editors with read-in and modifying functionality as well as the development of more sophisticated applications. Due to its high information content the STEP-NC standard is divided in one general and several technology specific parts. The corresponding division of the STEP-NC information model in several modules allows applications to support distinct technologies being in full conformance to the standard. The first workings on STEP-NC covered milling and drilling technology. Milling and drilling applications and machining tests already showed major benefits of STEP-NC compared to the existing ISO 6983 standard. The development of the turning data model and applications forms the next step on STEP-NC’s way to a comprehensive standard data interface for manufacturing [1].
2. REVIEW WORK

Review focus on major component on the research including milling, turning, turn-mill, STEP-NC framework and communication tools.

2.1 MILLING

A milling machine is a machine tool used to machine solid materials. Milling machines exist in two basic forms: horizontal and vertical, which terms refer to the orientation of the cutting tool spindle. Unlike a drill press, in which the work piece is held stationary and the drill is moved vertically to penetrate the material, milling also involves movement of the work piece against the rotating cutter, the latter of which is able to cut on its flanks as well as its tip. Work piece and cutter movement are precisely controlled to less than 0.001 in (0.025 mm), usually by means of precision ground slides and lead screws or analogous technology. Milling machines may be manually operated, mechanically automated, or digitally automated via computer numerical control (CNC), Data model for milling can be referring to ISO 14649 Part 11 Process Data for Milling [2].

2.2 TURNING

Turning is the process whereby a single point cutting tool is parallel to the surface. It can be done manually, in a traditional form of lathe, which frequently requires continuous supervision by the operator, or by using a computer controlled and automated lathe which does not. This type of machine tool is referred to as having computer numerical control, better known as CNC, and is commonly used with many other types of machine tool besides the lathe. Data model for milling can be referring to ISO 14649 Part 12 Process Data for Turning. The turning processes are typically carried out on a lathe, considered to be the oldest machine tools, and can be of four different types such as straight turning, taper turning, profiling or external grooving. Those types of turning processes can produce various shapes of materials such as straight, conical, curved, or grooved work piece. In general, turning uses simple single-point cutting tools. Each group of work piece materials has an optimum set of tools angles which have been developed through the years [3].

2.3 TURN-MILL

A combination between data model for milling (ISO 14649 Part 11 Process Data for Milling) and data model for turning (ISO 14649 Part 12 Process Data for Turning). A number of turning and turn-mill machining oriented papers have been published as well: Rosso investigated the use of STEP-NC in manufacturing of asymmetric rotational components. It was the researchers’ conclusion that the ISO14649 part 10 milling standard milling features are capable of supporting the features that these complex components require. The necessary data models were created and tested through a prototype system. This research has now been extended by Yusof with the development of an interoperable STEP-NC compliant data model and CAM system for representing and machining of turn–mill components [4].

3. COMMUNICATION TOOLS

Communication tools base on wireless and android base platform.

3.1 WIRELESS
The wireless communication removes the restriction of wired connections and support fast access to the Internet. Wireless devices alter the need of hardware-software co-design to remove the problems of present Wireless scenario. Nowadays the wireless technology enables the connectivity between two or more device to communicate using standard network protocols. Any fixed infrastructure and cabling system does not require for wireless networking or technology and most popular and successful wireless networks architecture is WiFi (wireless fidelity) and it is based on a serial standard of IEEE 802.11 [5]. Nowadays, WiFi provide the service in the various locations like as home, restaurant, public zone including airports, etc. and WiFi is a portable and low cost technique. In WiFi technology, for the connectivity point of view the Wireless network use an access point, or base station. In this type of network the access point acts like an active hub to provide Wireless connectivity between the computers and mobile phone.

3.2 ANDROID OS

The platform was originally created by Android Inc., which was then later bought by Google and released as the AOSP (Android Open Source Project) in 2007. This announcement was accompanied by the founding of the OHA (Open Handset Alliance), a consortium dedicated to develop and distribute Android. The software has been released under the Apache license as a free open source license. Thanks to the rapid development, a new major release of Android takes place every few months [6]. Unlike other mobile operating systems such as Windows Phone or iOS, Android applications are written in Java and run in a Dalvik VM (Virtual Machine). This virtual machine is a core component, because all Android applications and the application framework are executed by it. Similar to other platforms, applications can be obtained from a dedicated place called Google Play [7].

4. BACKGROUND OF RESEARCH

The changing economic climate has made global manufacturing a growing reality over the last decade, forcing companies from east and west and all over the world to collaborate beyond geographic boundaries in the design, manufacture and assemble of products. The ISO10303 and ISO14649 Standards (STEP and STEP-NC) have been developed to introduce interoperability into manufacturing enterprises so as to meet the challenge of responding to production on demand. Due to the complexity of programming there is a need to model their process capability to improve the interoperable manufacturing capability of machines such as turn/mill centres. The current ISO 6983 or current CNC regime is considered to rely on low level codes such as the description of tool movements and switching instructions. Figure 1 show the actual process chain for the ISO 6983.

Today with the latest technology the information beyond tool movement and switching instruction such as tooling, manufacturing features and process sequences are needed to support global adaptability for manufacturing with a specific focus on CNC-based manufacture. STEP-NC is considered to have the necessary rich information including “what to make” and “how to make”. Nowadays, a new standard namely ISO 14649 known as STEP-NC is being developed by vendors, users and academic institutes world wide to provide a data model for a new intelligent CNC, figure 2 show the STEP-NC process chain. The data model represents a common standard specifically aimed at NC programming, making the goal of a standardized CNC controller and NC code generation facility a reality [8].
Figure 1. Actual process chain

Figure 2. STEP-NC process chain
5. RESEARCH FRAMEWORK

Framework consists of 3 main STEP-NC interface frameworks, integrated data environment with CAD/CAM system.

5.1 FRAMEWORK 1: Imports & exports STEP-NC data

The generation of the ISO14649 output is created by mapping the native CAD/CAM information structures onto the STEP compliant data through a post processor specifically for ISO 14649. A major issue for this basic form of STEP compliance is that the CAD/CAM information stored on manufacturing technology (e.g. materials, tooling, clamping and machining strategy data) has to be converted into ISO 14649 formats via the post processor. It should be noted that many of the current CAD/CAM systems will probably not have the flexibility to incorporate this STEP output, as the output is so different to the normal G/M code output plus further data is required on the geometry of the component not just machining data [9].

![Figure 3. Framework 1: Imports & exports STEP-NC data](image)

5.2 FRAMEWORK 2: External STEP-NC interfaced CAD/CAM environment

The CAD/CAM system is integrated with an external software system to provide the STEP compliant data management support. Figure 4 shows framework 2: External STEP-NC interfaced CAD/CAM environment.
5.3 FRAMEWORK 3: Internally shared STEP-NC CAD/CAM environment

Figure 5 show framework 3: Internally shared STEP-NC CAD/CAM environment. This case represents a CAD/CAM system, which has a dual internal representation of geometric and manufacturing data, both in the native format of the CAD/CAM system and in the ISO 14649 format. Thus in the operational use of the system both sets of data are updated in real time rather than generating the STEP output through a post processor or having the STEP information structures in an external software environment.
6. WIFI ARCHITECTURE

In recent years, wireless and wired systems to communicate with other devices of the same ability have been one of the fastest-growing research areas. Significant progress has been made in many domains, such as machine-to-machine (M2M) communications, wireless sensor networks (WSNs), and wireless body area networks (WBAN) [10]. Typically, M2M refers to the communications among computers, embedded processors, smart sensors, smart actuators, and mobile terminal devices without or with limited human intervention [11]. The rationale behind M2M communications is based on two observations: 1) a networked machine is more valuable than an isolated one; and 2) when multiple machines are effectively interconnected, more autonomous and intelligent applications can be generated. Therefore, the development of M2M communications generates a lot of new opportunities for information industry. The impacts of M2M communications will continuously increase in this decade according to previous predictions [12]. Nowadays, the various applications of M2M have already started to emerge in several fields, such as healthcare, smart home technologies, manufacturing systems, and smart grids [13].

![Figure 6. Structure communication between CNC machine and Android application](image)

7. CONCLUSION

The authors believe this structure, will form the basis of new developments for STEP-NC communication between CNC machine and Android application through WiFi technologies, and will also provide the direct and simplest generation of ISO14649 NC code. One overhead of this framework will be the need to post process the STEP data into ISO6983 G/M code output for conventional CNC controllers.

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REFERENCES

[1] http://www.steptools.com, accessed on: 25/08/2010.
[2] Xu, X.W. (2006). “Realization of STEP-NC Enabled Machining” Robotics and Computer-Integrated Manufacturing 22, pp.144–153.
[3] X.W. Xu and S.T. Newman, “Making CNC machine tools more open, interoperable and intelligent—a review of the technologies,” Computers in Industry, vol. 57, n. 2, pp.141-152, February 2006.

[4] Yusof, Y. (2009), “STEP-NC-Compliant System for the Manufacturing Environment”, World Academy of Science, Engineering and Technology 49, Dubai. pp 935-940.

[5] IEEE Standard 802.11 i: Amendment 6: Medium Access Control (MAC) Security Enhancements. April 2004.

[6] Android Developers webpage, http://developer.android.com/index.html, accessed on: 10/02/2015.

[7] Wang C., Duan W. Ma J., Wang C. (2011). The Research of Android System Architecture and Application Programming. ICCSNT.

[8] International Standard Organization (2002), ISO 14649 Part 10 General Process Data.

[9] S T Newman, R D Allen and R S U Rosso Jr. (2002). “CAD/CAM solutions for STEP Compliant CNC Manufacture,” AMT Centre, Wolfson School of Mechanical & Manufacturing Engineering.

[10] Chen, M., Gonzalez, S., Vasilakos, A., Cao, H., Leung, V.: Body Area Networks: A Survey. ACM/Springer Mobile Networks and Applications, Vol. 16, No. 2, 171-193. (2011)

[11] Wan, J., Li, D., Zou, C., Zhou, K.: M2M Communications for Smart City: An Event-based Architecture. In Proc. of the 12th IEEE International Conf. On Computer and Information Technology, Chengdu, China, 895-900. (2012)

[12] Fadlullah, Z. M., Fouda, M. M., Kato, N., Takeuchi, A., Lwaski, N., Nozaki, Y.: Toward Intelligent Machine-to-Machine Communications in Smart Grid. IEEE Communications Magazine, Vol. 49, No. 4, 60-65. (2011)

[13] Chen, M., Wan, J., Li, F.: Machine-to-Machine Communications: Architectures, Standards, and Applications. KSII Transactions on Internet and Information Systems, Vol. 6, No. 2, 480-497. (2012)