International Journal of Innovation and Scientific Research
ISSN 2351-8014 Vol. 22 No. 1 Apr. 2016, pp. 178-182

http://www.ijisr.issr-journals.org/

A Glance about the Applications of Robot in Orthodontics

Ahmad S. Kh. Salamah and M.S. Drogomyretska

[1]Doctor of Medicine, Specialist in Orthodontics, Subspecialty in Pediatric Orthodontics, Ukraine

[2]Professor at National Medical Academy of Post-Graduate Education named after P.L.Shupyk, Kyiv, Ukraine

ABSTRACT: The purpose of this paper is to review the application of robot in Orthodontics. Application of robot in orthodontics is a novel application of robotic technology in medical field. This kind of robot can offer more precision, better results, and a beautiful smile in less time than conventional braces.

KEYWORDS: Robot, Orthodontics, medical field.

1 INTRODUCTION

Application of robot in surgery and other medical fields reminds us that an automatic system may also be able to play an important role in orthodontics. High-powered computers and advanced robotics continue to move forward in the field of orthodontics. An example of one of the new companies entering this field is SureSmile. They offer a system which combines three-dimensional computer imaging, exotic alloys and robotics. The company is claiming to reduce orthodontic treatment time, not move teeth any faster, but by moving teeth more efficiently. The technology is new and there is little research to validate their claim so far [2].

2 APPLICATIONS OF ROBOT IN ORTHODONTICS

The procedure starts with a scanning of the teeth. This can be accomplished by a cone beam scanner or by handheld scanner. The 3D image information is fed to a computer for further refinement. The location and tension needed for the brackets and wire is fed into the computer by Dr. Newhart and the information is sent by Internet to the Sure Smile facility. Now the robots come in. The orthodontic wire is gripped by two robotic pincers, which heats and bends the wire into a pattern that will guide the teeth into their preferred position.

Orthodontics Archwire Bending Robot: A robotic bending apparatus for automatically bending orthodontic archwires into a particular shape, which is shown in Figure 1, is presented by Werner Butscher[3]. The bending apparatus is known as SureSmile archwire bending robot. The bending apparatus comprises a robot mounted to a base or table support surface. A first gripping tool has a structure for holding the archwire or other medical device and is either be fixed with respect to the base or may be incorporated into a moveable arm. The second gripping tool is mounted to the end of a moveable six-axis robot arm having a proximal portion also mounted to the base and a distal end that can move relative to the fixed gripping tool about three translational and three rotational axes. Preferably, the gripping tools incorporate force sensors which are used to determine overbends needed to get the desired final shape of the archwire and may also include a resistive heating system in which current flows through the wire while the wire is held in a bent condition to heat the wire and thereby retain the bent shape of the wire. SureSmile is an all-digital system which uses new 3-D imaging and computer techniques for diagnostics and treatment planning and uses robotics to customize fixed orthodontic appliances [4].

Corresponding Author: Ahmad S. Kh. Salamah

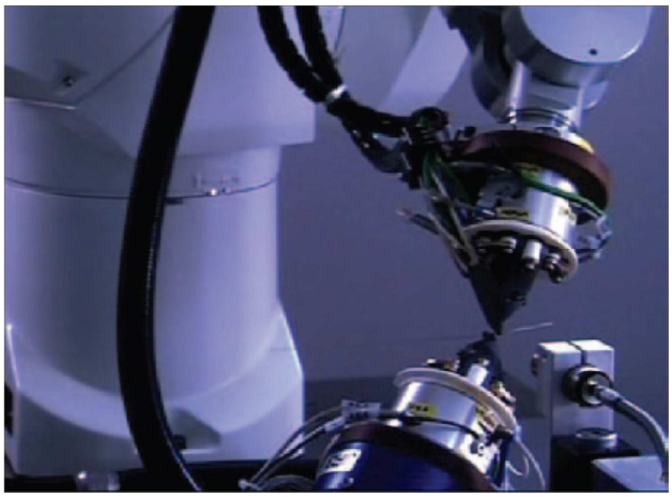

Figure 1: SureSmile archwire bending robot.

Treatment can be simulated in advance and different treatment strategies can be visualized; this allows detailed treatment planning. The application of CAD/CAM aims at improving reproducibility, efficiency, and quality of orthodontic treatment. A lingual archwire manufacturing and design aid (LAMDA) for the accurate, rapid design, and bending of the orthodontic archwire, which is shown in Figure 2, is established by Gilbert. This system can only realize the movement in XY plane. So it cannot bend the archwire with closed loop [5]. Archwire bending robot based on MOTOMAN UP6 is shown in Figure 3.The archwire bending robot is composed of PC,MOTOMAN UP6, and the archwire bending actuator. The actuator matches with the end of the MOTOMAN robot. The archwire bending actuator which connects with the MOTOMAN robot end is used to clamp and bend the archwire [5].

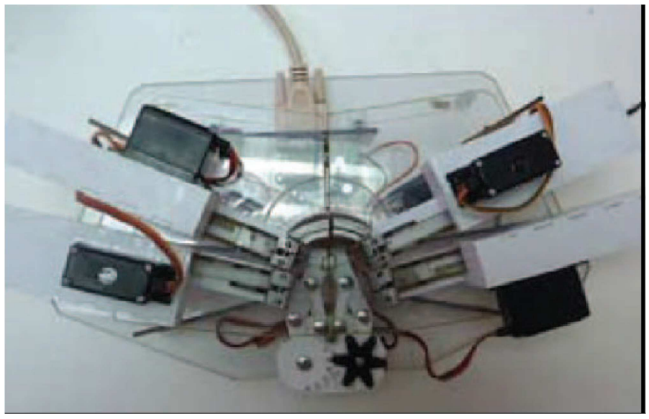

Figure 2: LAMDA system

Figure 3: Archwire bending robot based on MOTOMAN UP6

Control software structure of archwire bending robot based on MOTOMAN UP6 is shown in Figure 4.The bending process, the bending point's position and angle optimization of the archwire, the kinematics of this robot, and bending properties of four type archwires are analyzed and simulated[5]. Cartesian type archwire bending robot is shown in Figure 5.

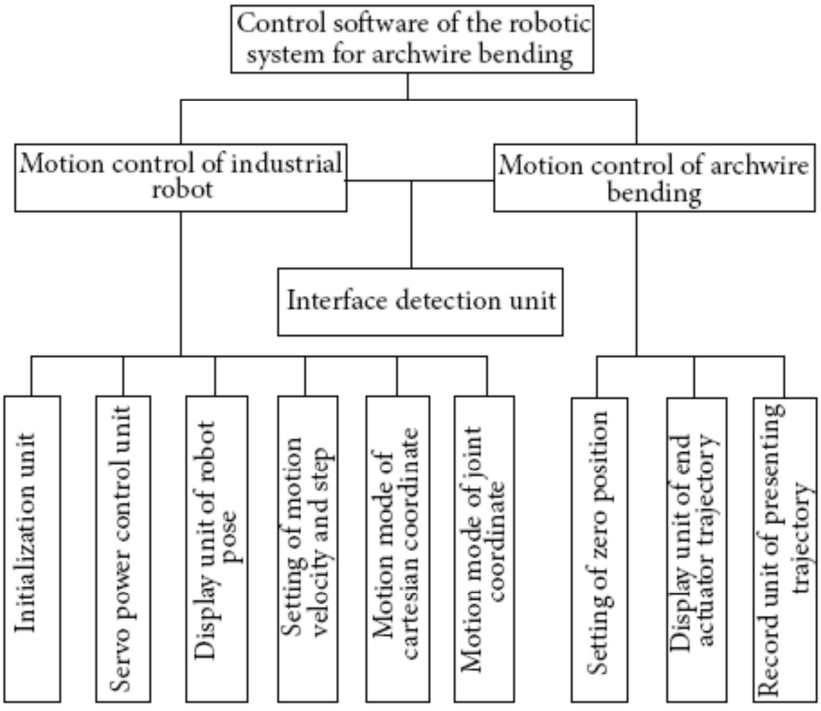

Figure 4: Control software structure of archwire bending robot based on MOTOMAN UP6.

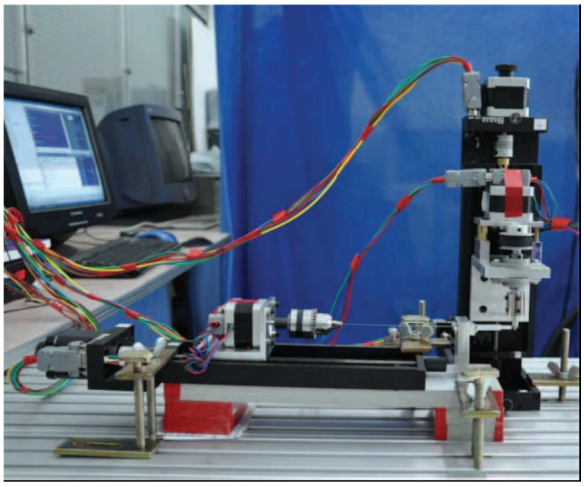

Figure 5: Cartesian type archwire bending robot.

Archwire bending robot mechanism is composed of the base, the rotary, feed, and supporting structure of archwire, bending die, and archwire bending mechanism[6]. Bending process orthodontic archwire is analyzed and structure of orthodontic archwire bending robot is designed using Solidworks software. Precision control with a third-order pure S acc/dec profile of archwire bending robot is established. Orthodontic archwire bending experimentation is performed using Cartesian type archwire bending robot. Figure 6 shows the orthodontic archwire made by the archwire bending robot system[6].

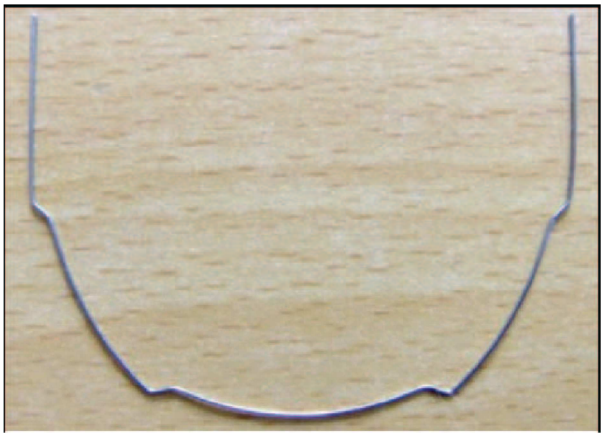

Figure 6: Orthodontic archwire made by the Cartesian type archwire bending robot system.

3 KEY PROBLEMS AND FUTURE DEVELOPMENT ON APPLICATION OF ROBOT IN ORTHODONTICS

1. Basic Requirement of Design: Qualitative description language in orthodontics is transferred to quantitative description. With the help of three-dimensional oral character the bending of archwire are realized automatically by the limited space robot. Main difficulty of the design and manufacturing for robot in orthodontics is whether it can satisfy the demand of the different patient's mouth characteristics after oral repair. For orthodontics archwire bending robot, orthodontics archwire should be quantitatively expressed. Archwire spring-back and bending point's planning should be analyzed to realize the accurate archwire bending.
2. Research Difficulty: Function of the application of robot in orthodontics is different, so the research difficulty also is not identical. Research difficulty of orthodontics archwire bending robot system is spring-back analysis and bending algorithm of archwire and generation of personalized orthodontics archwire.

3. Future Development on Application of Robot in Orthodontics: Progress has been made in the research of the application of robot in orthodontics, but it is not complete. Viewing from the state of the art of application of robot in orthodontics and the market demand of oral cavity repair, the following research aspects should be done in the future[7]..

(1) Novel Structure. High flexibility, reliability, and accuracy are needed for the robot in orthodontics, but the workspace is limited by the oral cavity. The flexibility and the limited workspace are one pair of technical contradictions, so the total planning and optimization to the robot is necessary. In the precondition of satisfying the oral cavity repair, the reducing of degree of freedom of the robot is necessary. Using the dual relation in structure and property of serial robot and parallel robot, requirements for the structural design of robot in prosthodontics and orthodontics are met by combining the high accuracy and simplified mechanical structure performance of parallel robot and the flexibility operation of serial robot.

(2) Sensor and Control Technique. For orthodontics archwire bending robot, the research in the future focuses on archwire spring-back and bending algorithm.

(3) Human-Computer Interaction Technology. Human-computer interaction technology is one of the key technologies of motion control of the robot in orthodontics. For orthodontics archwire bending robot, the research in the future focuses on three-dimensional virtual display of personalized orthodontics archwire on the screen, a virtual observation environment for a designed personalized orthodontics archwire, and the position's interactive modification of different loop. For the robot in orthodontics, it is difficult to detect working condition and realize the operation with multiple obstacles unstructured environment. For facilitating the operation, a kind of friendly human-computer interaction software should be designed to provide humanization input and feedback for the operators[8]..

4 CONCLUSION

It can accomplish the great revolution from qualitative to quantitative of orthodontics, and it has been an important development direction of medical robot. State of the art of application and research of robot in orthodontics is introduced, and the basic requirements and research difficulties of robot in orthodontics are pointed out; finally, the research of robot in orthodontics in the future is expected from three aspects, such as new structure, sensor and control technique, and human-computer interaction technique.Various countries in the world have taken helpful exploration in robot to dental implantology and orthodontics archwire bending, but it still remains at theoretical research and preliminary experiment level. With the development of correlation technique and theory, such as new structure, and sensor and control theory, the robot will be widely applied in orthodontics.

REFERENCES

[1] Y. D. Zhang, C. G. Wei, J. G. Jiang, J. X. Jiang, Y. Liu, and Y. Wang, "Motion planning for archwire bending robot in orthodontic treatments," International Journal of Control and Automation, vol. 7, no. 7, pp. 287–297, 2014.

[2] J. G. Jiang, T. H. He, Y. Dai, and Y. D. Zhang, "Control point optimization and simulation of dental arch generator," Applied Mechanics and Materials, vol. 494-495, pp. 1364–1367, 2014.

[3] J. Rigelsford, "Robotic bending of orthodontic archwires," Industrial Robot, vol. 31, no. 6, pp. 321–335, 2004.

[4] T. J. Alford, W. E. Roberts, J. K. Hartsfield Jr., G. J. Eckert, and R. J. Snyder, "Clinical outcomes for patients finished with the SureSmile method compared with conventional fixed orthodontic therapy," The Angle Orthodontist, vol. 81, no. 3, pp. 383–388, 2011.

[5] H. Du, Y. Jia, Y. Zhang, and Y. Liu, "Trajectory planning of archwire bending robot," ChinaMechanical Engineering, vol. 21, no. 13, pp. 1605–1608, 2010.

[6] Y. D. Zhang and J. X. Jiang, "Study on precise acceleration/ deceleration planning of archwire bending robot," ICIC Express Letters, vol. 7, no. 1, pp. 73–78, 2013.

[7] Y. D. Zhang, J. G. Jiang, T. Liang, and W. P. Hu, "Kinematics modeling and experimentation of themulti-manipulator tootharrangement robot for full denture manufacturing," Journal of Medical Systems, vol. 35, no. 6, pp. 1421–1429, 2011.

[8] J. G. Jiang, Y. D. Zhang, and W. Y. Zhang, "Collaborative simulation and experimentation of dental arch generator of multimanipulator tooth arrangement robot," International Journal of Advanced Robotic Systems, vol. 9, pp. 1–9, 2012.