Smooth Curve of B-Spline with Ordo K or Node K

Wikaria Gazali
Mathematics Department,
School of Computer Science,
Bina Nusantara University
Jl. K.H. Syahdan No.9, Palmerah
Jakarta 11480, Indonesia
+62 8129561430
wikaria@binus.edu

Djunaidy Santoso
Computer Science Department,
School of Computer Science,
Bina Nusantara University
Jl. K.H. Syahdan No.9, Palmerah
Jakarta 11480, Indonesia
+62 87782517754
djunaidys0533@binus.ac.id

ABSTRACT
The background of this research is an early stage of the use of Spline Art graph theory, namely in the construction techniques of objects that will be required or used in the design model of objects / car / aircraft and other construction. There are two basic objectives for the use, which are first to facilitate and deepen the basic knowledge of polynom spline art principles by understanding the correct use of the polynom spline art formula. The second mastery of this theme is the need to produce a graphical system, which is based on the polynom spline art formula. The use of polynom spline art is a large number in the field of construction of object graphs. This Research takes into account the node K of the B-spline blending function. The method used is based on the polynom spline-art theory. The results to be achieved, namely the model of making objects based on polynom spline Art. In this research using programming language to describe and achieve the goal, that is graph by using simple openGL and make in general and can record the structure of good data.

Keywords
polynom spline art, graphical system, openGL

1. INTRODUCTION
With more algorithms in the field of computer graphics, more time will be required to decide and determine the appropriate algorithms to use. Therefore a research is necessary to determine the best algorithms to be used when dealing with curves and need to be according to the users needs. Problem Identification : From the industry's or other institution's statistical data, many curves are generated however the curves are not smooth, such that it can not be used by the industry or organization. [1][5][6][7]

Specific Objectives

This research is developed with the objectives and benefits as follows:

To develop a curve/image for automotive industries (machinery), ships and aeroplanes and building designs. This Research takes into account the node K of the B-spline blending function.

To analyze and develop well-shaped curves or to develop a smooth curve from images obtained from sattelites (GIS).

To be used in the fields of statistics, hospitals, and other industries.

2. RESEARCH METHODOLOGY
As described earlier, this research will be conducted using the following methodology :

Literature studies, is performed by searching data and information on the internet. This is conducted in order to get the latest and most updated information regarding the methods and model in this research, and also to research the existing and currently used methods. Data analysis is performed to analyze all the collected data. This Research takes into account the node K of the B-spline blending function. System development is performed to obtain the user's requirements and the system requirements. System implementation is performed to create and develop a model/simulation using a software/application which is developed by writing a program. Testing dan evaluating the system. Testing is conducted using the system application and the developed model, checking wether it is according to the user's requirements.

Research Plan Schedule

First Step: Creating the design mode

The first step is to perform a literature research, data and information searching, from books or the internet, in order to get the latest information on the development of this method and the research model, and also to research the existing model. Then searching for actual information and facts from other institution. The data collected [3] empirically is used as a means to develop the model and the relationships among data sources, in terms of the advantages of using Bezier algorithm and B-Spline[5][6].

Second Step: Model Implemetation

The model obtained from the survey is then implemented in a software that can be used by the institution or department in the areas surveyed. In addition to the software, a guide is also developed for users to facilitate users whom working with the software. Feedback from users are used as an evaluation to assess the implementation of the model for further refinement. Evaluation of the implementation is done by using a questionnaire to obtain feedback.

Third Step: Model verification

Verification of the early model equations are used and the results of a survey on the use of the software is developed. In order to research the design, the influence of the system software is analyzed. It includes the possibility of research in other domain of Soft-Computing. Main focus on graphics system will be placed

around numbers, letters, pictures and objects which are commonly used as key factors in industry.

This designing method is also based on system life cycle development so as to facilitate the designer to develop or maintain the system quickly and well.

Research in the field of this system is directed in line with the road map of research in Informatics Engineering at Bina Nusantara University. Curve Approximation Program is used for design curves, design pictures, and object. The results of the program construction are used for government agencies, universities and companies in need. Curve Approximation Program need user Interface, language programming C++ and construction of this Programm used System Development Life Cycle.

We need also Database Management System for this program construction [1][2][3][4][5][6][7].

DISCUSSION for B-SPLINE

Curve B-spline is Bernstein Method with special properties. This base is non-global, so each point of Bi with a different basic functions, so that every point of the curve affects only in areas with base parameter values where the function is not zero

3.1 Curve B-spline

This Research takes into account the node K of the B-spline blending function.

Basically the general requirements of B-Spline curve is almost equal to the requirements of the Bezier curve. For the B-spline curve of order k (degree k-1) each point of the curve should be in the convex hull of k adjacent point. Then the whole point of the B-Spline curve must be in join from around the convex hull formed by k control points. In the figure below are shown the effects of differences in the value of k. Note that k = 2 convex hull is a polygon defining itself.

B-Spline method is the development of Bezier methods, but differ with Bezier curves, on the B-Spline curve control points influence the shape of a curve as a whole. Change one of the existing control point coordinates will only change the shape of the curve on the segment near the control point. This is because the segment of the curve is only affected by a number of control points which was near

Mathematical equation B-Spline curve with a parameter defined as follows:

(Source [1] [2] [11] [13])

Number of B-Spline function for some value of parameter to be in the show: Ref. [5], [6]

$$\sum_{i=1}^{n-1} N_{i,k}(t) = blending \quad function \qquad (1)$$

$$P(t) = \sum_{i=1}^{n-1} B_i N_{i,k}(t), \quad t_{min} \le t < t_{max} \qquad (2)$$

$$2 \le k \le n+1$$

3.2 Number of B-Spline function for some parameter value K = 1 to the following

$$\sum_{i=1}^{n+1} N_{i,k}(t) = 1$$

Description :

• Each basis function is positive or zero for all values of the parameters, namely Ni,k > 0 .

• Except for k = 1 each basis function has a maximum value of 1.

• The maximum level of the curve equals the number of control point polygon.

• Curve follows the shape of a polygon control points.

• Curve lies in the convex hull of the polygon points.

Open uniform knot vector B-spline, which has a number of points at the ends of the value equal to k levels of B-Spline functions. Some of the open uniform sample point with the vector k : This research takes into account the node K of the B-spline blending function.

If the number of points = 4 → n = 3 the number of points - 1

K= 0 no curve ; K=1 is step function → Polynom order / grad 0 ; K= 2 polygon

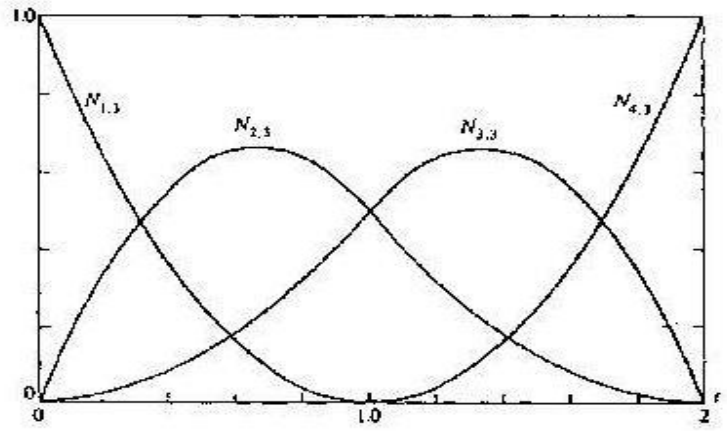
K = 2 [0 0 1 2 3 3] number knotvector = n+k+1=6 0<=t<=3-2+2=3

K = 3 [0 0 0 1 2 2 2] number knotvector =3+3+1=7 0<=t<=3-3+2=2

K = 4 [0 0 0 0 1 1 1 1] number knotvector = 3+4+1=8 0<=t<=3-4+2=1

Parameter t move from 0<= t <=n-k+2

Blending Function of B-Spline : This research takes into account the node K of the B-spline blending function



Example B-Spline Curve :

B-SPLINE RESEARCH :

At the same point as the research B-Spline functions: first calculate knot vector and put those values to the function of B-Spline blending and obtained polynom B-Spline function from a given point: P0(2,6) P1(4,12) P2(7,3) P3(9,10).

This research takes into account the node/order K of the B-spline blending function.

With order of K = 2, we have :

Po(t=0) = (2 / 6) ; P1(t=0.5) = (3 / 9) ; P2(t=1) = (4 / 12) ; P3(t=1.5) = (5.5/ 7.5)

P4(t=2.0) = (7 / 3) ; P5(t=2.5) = (8.0 / 6.5) ; P6(t=3.0) = (9 / 10)

With order/node of K = 3, we have :

Po(t=0) = (2 / 6) ; P1(t=0.5) = (3.875 / 9.375) ; P2(t=1) = (5.5/ 7.5) ;

P3(t=1.5) = (7.125 / 5.875) ; P4(t=2.0) = (9 / 10)

With order of K = 4, we have :

Po(t=0) = (2 / 6) ; P1(t=0.5) = (5.5 / 7.625) ; P2(t=1) = (9/ 10)

Curve Obtained :

P0(2,6) ; P1(4,12) ; P2(7,3) ; P3(9,10) ; K = 2 form Polygons ; K = 3 form curves like sine ; K = 4 ; B-Spline curve shape is pure = Bezier curves.

The Goal of Research

This Research was developed with the purpose and benefits, which are as follows:

To design curves / images / images for the automotive industry (drawing machines), aircraft / sea, home design. This Research takes into account the node K of the B-spline blending function.

To analyze well or design / create curves / images seamlessly like satellite images (GIS) with new formulation of Blending Function algorithm / Harmonization Function curve.

For use in statistics and Hospital and Printing industry and others.

RESEARCH TARGETS

Forming a good method or formula that can be dedicated to applications in Industry.

OUTPUTS OF RESEARCH PLAN

There should be some output that supports the outcomes that need to be achieved to design any desired construction. Now this outcome is not so smooth the curve created because of the factor of concern for:

- This Research takes into account the node K of the B-spline blending function
- Blending function formula is used.
- The CPU is less fast the process, the program module for

Designing the construction of any object has not been good,

- Improper monitor of its pixels (Bresenham algorithm)

Which is poorly supported by Picture Element (PIXEL) so must choose a good Monitor

for Output, So they can make decisions quickly in terms of choosing the best curve.

BENEFITS OF RESEARCH

For use in the field of statistics and Hospital as well as the printing industry and others, for good or smooth curves, the industry needs, because this research takes into account the node K of the B-spline blending function

Specialization of Soft-Computing Department of Informatics Bina Nusantara University directs its graduates as application developers of information systems especially in the field of Graphics and Computing. It is possible to research on other Soft-Computing domains.

Graphics system is useful in the industry to manufacture objects in the form of numbers, letters, drawings and objects that need of the users.

4. PRODUCTS OF RESEARCH RESULTS

In this field needs to be deepened or developed because it is a much in demand by an industry that increasingly thinking about business, because the product of goods using the algorithm is very profitable industry.

In making this design need a system design method, also required a reliable data system and screen design methods are convenient for users, so the output obtained faster, accurate and as needed, because the software is made using the menus are easily digested. So it can help decision making from the users.

Points are given :

Po = 2/1 ; P1 = 6/8 ; P2 = 9/4 ; P3 = 11/6

Open uniform knot vector B-spline, which has a number of points at the ends of the value equal to k levels of B-Spline functions. Some of the open uniform sample point with the vector k :

If the number of points = 4 → n = 3 the number of points - 1

K= 0 no K=1 is step function → Polynom order / grad 0

K= 2 polygon

K = 2 [0 0 1 2 3 3] number knotvector= n+k+1=6 0<=t<=3-2+2=3

K = 3 [0 0 0 1 2 2 2] number knotvector=3+3+1=7 0<=t<=3-3+2=2

K = 4 [0 0 0 0 1 1 1 1] number knotvector= 3+4+1=8 0<=t<=3-4+2=1

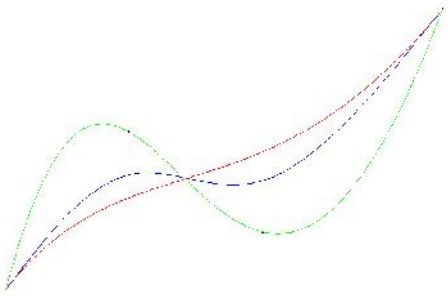
Parameter t move from 0<= t <=n-k+2

B-Spline curve can be seen below : This research takes into account the node/ordo K of the B-spline blending function

Product B-Spline Curve

Sample example : drawing interpolation curve (green color), Bezier curve (red color), B-Spline curve (Blue color)

This research takes into account the node K of the B-spline blending function



5. CONCLUSION

From the test result, a conclusion can be drawn as follows:

That the program is sufficient, the data model is drawing according to the algorithms and the result is that the curves are better (more smooth) as required by the user. Example:

Po = 2/1 ; P1 = 6/8 ; P2 = 9/4 ; P3 = 11/6

Open uniform knot vector B-spline, which has a number of points at the ends of the value equal to k levels of B-Spline functions see (1), (2) above . Some of the open uniform sample point with the vector k, so that we can look at the blue curve above. See section 4 : PRODUCTS OF RESEARCH RESULTS. So that the Blue Curve is smoother.

Suggestion for further research:

The requirement to evaluate the hardware, especially the monitor with high resolution and adequate CPU requirements, as the data can be very large in size, and a comparison of the algorithm with other curves. Menu displays can be either stactic or dynamic.

6. ACKNOWLEDGMENTS

Appreciation to the Ministry of Research Technology and Higher Education of Republic of Indonesia, which has provided support to the author through 2018 Research Grants.

7. REFERENCES

[1] Newman,W. M. & Sproull R.F. 1981. Principles of Interactive Computer Graphics. Kogakusha, McGraw-Hill.

[2] F.David & Rogers & Adams J.A. 1998. Mathematical Elements for Computer Graphics. New York: McGraw-Hill.

[3] Theo Pavlidis. 1997. Algorithms for Graphics and Image

[4] Wolfgang K.Giloi. 1999. Interactive Computer Graphics. Prentice Hall,Inc. Englewood Cliffs, New Jersey 07632.

[5] Connolly, Thomas, And Begg, Carolyn. 2002. Database Systems. 3rd Edition. Addison Wesley Longman, Inc, USA.

[6] Elmasri, Ramez, dan Navathe, Shamkant B. 2000. Fundamental of Database Systems. Third Edition. Addison – Wesley Publishing Company, Inc, United States of America.

[7] Date, C. J. 1990. An Introduction to Database System. Addison Wesley Longman, Inc, USA.

[8] Ramakrishnan, Raghu, Gehrke, Johannes. 2003. Database Management Systems. 3rd Edition. The McGraw-Hill Companies, Inc, USA.

[9] Pressman, Roger S. 2001. Software Engineering : A Practioner' s Approach. 5thEd. MC Graw - Hill, New York.

[10] Shneiderman, Ben .1998. Designing the User Interface: Strategies for Effective Human-Computer Interaction. Third Edition. Addison-Wesley..

[11] Foley J. D. et al. 1996. Computer graphics : principle and practice. 2 Addison-Wesley Publi.Reading, Massachuset. ISBN: 0-201-12110-7.

[12] Woo, M. et al. 2006. OpenGL programming guide. 5 Addison. Wesley Publi. Reading, Massachuset. ISBN: 0-201-60458-2.

[13] Edward, A. (1990). Computer graphics. 1 Addison. Wesley Publi. Reading, Massachuset. ISBN: 0-201-13548-5.

[14] Hearn D., & Baker M. P. 1986. Computer graphics. 1. Prentice-Hall Intern. London. ISBN: 0-13-165598-1

[15] L Piegl, W Tiller. 2012. The NURBS Book 2nd Edition. Springer. ISBN 978-3-540-61545-3

[16] Z Purisha, S Siltanen. 2016. Tomographic Inversion Using NURBS and MCMC. Springer. ISBN : 978-3-319-16138-9

[17] A Gálvez, A Iglesias. 2012. Particle Swarm Optimization for Non-Uniform Rational B-Spline Surface Reconstruction from Clouds of 3D Data Points. Elsevier. Volume 192, 1 June 2012, Pages 174-192.

[18] NL Jones, DP Greenberg, KB Pratt. 2012. Fast Computer Graphics Techniques for Calculating Direct Solar Radiation on Complex Building Surfaces. Pages 300-312. https://doi.org/10.1080/19401493.2011.582154

[19] E Rank, M Ruess, S Kollmannsberger. 2012. Geometric Modeling, Isogeometric Analysis and the Finite Cell Method. Elsevier. Volumes 249–252, 1 December 2012, Pages 104-115

[20] M Breitenberger, A Apostolatos, B Philipp. 2015. Analysis in Computer Aided Design: Nonlinear Isogeometric B-Rep Analysis of Shell Structures. Volume 284, 1 February 2015, Pages 401-457

Your Name	Title*	Research Field	Personal website
Wikaria Gazali, S.Si., M.T.	Associate Professor	Applied Mathematics	http://www.geocities.ws/wikaria/
Djunaidy Santoso, Dipl.Ing., M.Kom.	Associate Professor	Computer Graphics	

***This form helps us to understand your paper better, the form itself will not be published.**

***Title can be chosen from: master student, Phd candidate, assistant professor, lecture, senior lecture, associate professor, full professor**