The Algorithm Design of the X/Y-axis Restrictive Amplification Function in the Well Test Interpretation Software and It's Implementation

Botao Liu[1, 2, a], Xinhai Wang[1, 2], Lihong Wan[2], Guoliang Li[3], Quanfu Bi[3], Jinli Wang[3], and Jinjun Xia[4]

[1]Key Laboratory of Exploration Technologies for Oil and Gas Resources (Yangtze University), Ministry of Education, Wuhan 430100, China

[2]College of Computer Science, Yangtze University, Jinzhou 434023, China

[3]Testing Oil Company, Western Drilling Engineering Company Limited, Karamay 834027, China

[4]Jinma Oilfield Development Company, Geology Institute of Liaohe Oilfield, Panjin 124010, China

[a]liubotao920@yahoo.com

Abstract. Research design and implementation of the X/Y-axis restrictive amplification function has a practical value in the software development. Especially in the well test interpretation software, there is a lot of log-log and semi-log coordinate system, this function is the basis of other functions. Therefore, under the rectangular and log coordinate system, the research and implementation of this function has become a necessary for the similar software development. In the paper, authors have given the coordinate conversion formula between the screen coordinate and the word coordinate under the rectangular, the log-log and the semi-log coordinate system, subsequently have discussed the algorithm design thinking of the X/Y-axis restrictive amplification function in the well test interpretation software, finally taking the well test interpretation software as example, which developed by the ideas in the VS2010 environment, have carried out a detailed test. And the test results show that the software is running correctly, reliably.

Keywords: Restrictive Amplification; Log Coordinate; Well Test Interpretation Software.

1. Introduction

In the development process for well test interpretation software [1-7], usually need to draw the log-log chart curve [8-9] and semi-log pressure curve, in order to carry out the related analysis and processing. In this process, in order to view the curve integral and local information, users sometimes keep the Y-axis range unchanged and amplify a certain X-axis region (Here called "X-axis restrictive amplification"), or keep the X-axis range unchanged and amplify a certain Y-axis region (Here called "Y-axis restrictive amplification"). Therefore, under the rectangular and the log coordinate system, for well test software development, the study of X/Y-axis restrictive amplification function is particularly necessary.

Research shows that, the literature [10] designed a program for finite element meshes local amplification according to the principle of coordinate translation. The literature [11] realized the image of local amplification by using pixel replication in the Delphi environment, introduced its principle and method, which can make any part of the image smooth zoom in. The literature [12] achieved the function of zooming in the local area selected by the rubber band. The literature [13] discussed the steeples zoom of the graph and gave the corresponding C language implementation. The literature [14] used the collected data to plot a graph, discussed the principle of the zoom in and zoom out, and gave the VB implementation. The literature [15] introduced the function that using OpenGL to realize the graph local zoom in from the perspective of computer graph in Visual C++ environment. The literature [16] using the principle of computer vision, taking the 3-D perspective graph display for example, solved the problem produced by coordinate transformation in using VC++ drawing graph, realized the image zoom function, and deduced several ordinary mathematical formula used for

coordinate transformation. The literature [17] discussed the log coordinate transformation, but did not give the zoom discussions under the log coordinate. The literature [18] systematic deduced the coordinate conversion formula under the rectangular, the log-log and the semi-log coordinate system, discussed the graph zoom function design and its algorithm implementation, but the X/Y-axis restrictive amplification function had not been discussed. It is not hard to see that, none of the above literatures had directly discussed how to design and implement the X/Y-axis restrictive amplification function under the rectangular, semi-log and log-log coordinate system.

The following, authors will give the coordinate conversion formula between the screen coordinate and the word coordinate under the rectangular and the log coordinate system, in combination with the well test interpretation software functional requirements, discuss the algorithm design thinking of the X/Y-axis restrictive amplification function, and give its VS2010 implementation and test results.

2. The Coordinate Transformation Algorithm Research

As is known to all, the method of drawing graphs in the computer is essentially based on one by one point and one by one curve. When a point is plotted on the screen, firstly the world coordinates value of the point is taken out, then it is converted into screen coordinates value by using of coordinate transformation formula, finally, the point is drawn on the screen in accordance with the relevant requirements (the shape, the color, the style and so on). Therefore, the curve display result depends on two factors: the world coordinate value of each point in the curve and the coordinate transformation formula.

There are a lot of kinds map mode in MFC environment. In order to ensure consistency of graph before and after mapping, authors use the mapping in the form of "Overall Shift", which is shown in figure 1 and its mapping rules are defined as follows: 1) Assumes that the drawing range of the user's interest in the world coordinate system as shown in the dashed frame in figure (2-a), the bottom left corner point coordinate is (X_{w1}, Y_{w1}) and the upper right corner point coordinate is (X_{w2}, Y_{w2}); 2)Assumes that the position of the drawing canvas on the drawing window client area as shown in the dashed frame in figure (2-b), the bottom left corner point coordinate is (X_{src1}, Y_{src2}), and the upper right corner point coordinate is (X_{src2}, Y_{src1}); 3)Map the point of (X_{w1}, Y_{w1}), which is both the minimum value in X, Y coordinate of the world coordinate, to the point of (X_{src1}, Y_{src2}), which is in the canvas of the screen coordinates; 4)Map the point of (X_{w2}, Y_{w2}), which is both the maximum value in X, Y coordinate of the world coordinate, to the point of (X_{src2}, Y_{src1}), which is in the canvas of the screen coordinates; 5)Assuming any other point (X_w, Y_w) in the world coordinate is mapped into the point (X_{src}, Y_{src}) in the screen coordinate; 6)The projection, generated by the graph in the X-axis and Y-axis, meet the linear relationship under before and after mapping.
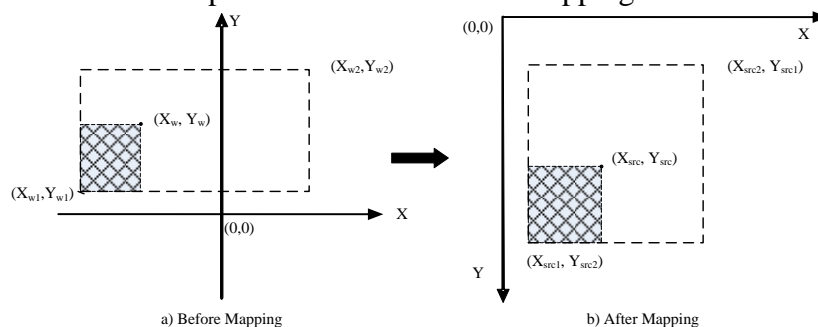

Figure 1 the Demo of Coordinate Transformation Algorithm

2.1 The coordinate Transformation Algorithm Research under the Rectangular Coordinate System.

The following can be obtained from the Figure 1 and the literature [18]:

$$X_{src} = X_{src1} + \frac{X_w - X_{w1}}{X_{w2} - X_{w1}}(X_{src2} - X_{src1}) \tag{1}$$

$$Y_{src} = Y_{src2} - \frac{Y_w - Y_{w1}}{Y_{w2} - Y_{w1}}(Y_{src2} - Y_{src1}) \tag{2}$$

Formula (1), (2) are transformation formulas between the worlds coordinate and the screen coordinate under the rectangular coordinate system.

2.2 The Coordinate Transformation Algorithm Research under the Log-log Coordinate System.

The following can be obtained from the Figure 1 and the literature [18]:

$$X_{src} = X_{src1} + \frac{\log_{10}(X_w/X_{w1})}{\log_{10}(X_{w2}/X_{w1})}(X_{src2} - X_{src1}) \tag{3}$$

$$Y_{src} = Y_{src2} - \frac{\log_{10}(Y_w/Y_{w1})}{\log_{10}(Y_{w2}/Y_{w1})}(Y_{src2} - Y_{src1}) \tag{4}$$

Formula (3), (4) are transformation formulas between the world coordinate and the screen coordinate under the log-log coordinate system.

2.3 The Coordinate Transformation Algorithm Research under the Semi-log Coordinate System.

In the well test interpretation software of similar to the literature [8-9], the X-axis is the log coordinate system and the Y-axis is the rectangular coordinate system. Thus mapping on the X-axis, turning the world coordinate value to screen coordinate value can be calculated by formula (3), and while mapping on the Y-axis, calculated by formula (2).

Similarly, if the X-axis is the rectangular coordinate system and the Y-axis is the log coordinate system, then the X-axis and Y-axis mapping respectively use formula (1) and formula (4).

3. The Function Design of Graph Restrictive Amplification and its Algorithm Research

3.1 The Function Design of Graph Restrictive Amplification.

Depending on the specific application requirements of well test interpretation software, graph restrictive amplification function can be designed as follows: In the graph restrictive amplification mode, generate a rubber band rectangle window in real time when users drag the mouse and amplify the selected region to the entire drawing area after users release the left mouse button. For the convenience of users, need to design two restriction amplification mode, which is respectively the X-axis restrictive amplification mode and the Y-axis restrictive amplification mode.

Therefore, in the two kinds of mode, the position of the window rubber band rectangle generated in real time is not the same. In the X-axis restrictive amplification mode, the range on the Y-axis of this window cover the entire graph area and the range on the X-axis should be determined by the user's drag-start point and drag-end point. Similarly, in the Y-axis restrictive amplification mode, the range on the X-axis of this window cover the entire graph area and the range on the Y-axis should be determined by the user's drag-start point and drag-end point.

3.2 The Algorithm Research of X-axis Restrictive Amplification Mode.

The implementation steps of the X-axis restrictive amplification is as follows: 1) Get the minimum value Y_{src1} and the maximum value Y_{src2} on Y-axis in the screen coordinate system; 2) When users drag the mouse, capture X_{msrc1} and X_{msrc2}, which is respectively the horizontal screen coordinate of the drag-start point and the drag-current point. Then generate a rubber band rectangle window in real time according to the point (X_{msrc1}, Y_{src1}) and the point (X_{msrc2}, Y_{src2}), for telling users the current amplification region, as shown in Figure (2-a); 3) When users finish dragging the mouse, respectively converted the X_{msrc1} and X_{msrc2} into world coordinates X_{mw1} and X_{mw2} using the foregoing coordinate transformation formula, as shown in Figure (2-b). Subsequently update world coordinates on X-axis, namely: $X_{w1}=X_{mw1}$, $X_{w2}=X_{mw2}$. Finally refresh the canvas to redraw the graph to achieve the restrictive amplification.
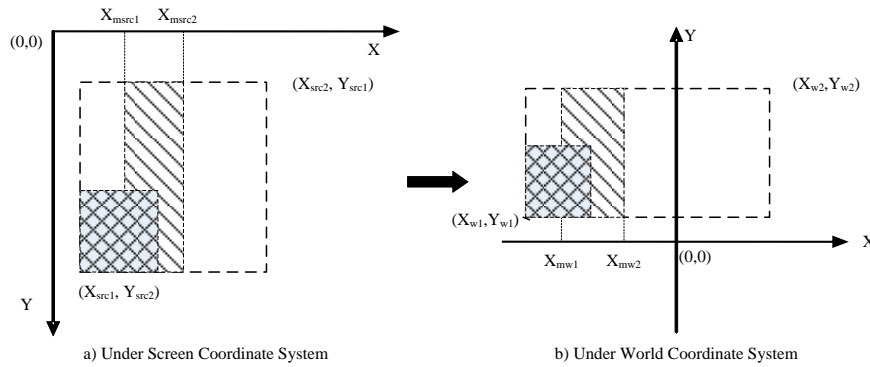
a) Under Screen Coordinate System   b) Under World Coordinate System

Figure 2 the Demo of X-axis Restrictive Amplification Algorithm

3.3 The Algorithm Research of Y-axis Restrictive Amplification Mode.

Similarly, the implementation steps of the Y-axis restrictive amplification is as follows: 1) Get the minimum value X_{src1} and the maximum value X_{src2} on X-axis in the screen coordinate system; 2) When users drag the mouse, capture Y_{msrc1} and Y_{msrc2}, which is respectively the vertical screen coordinate of the drag-start point and the drag-current point. Then generate a rubber band rectangle window in real time according to the point (X_{src1}, Y_{msrc1}) and the point (X_{src2}, Y_{msrc2}), for telling users the current amplification region, as shown in Figure (3-a); 3) When users finish dragging the mouse, respectively converted the Y_{msrc1} and Y_{msrc2} into world coordinates Y_{mw1} and Y_{mw2} using the foregoing coordinate transformation formula, as shown in Figure (3-b). Subsequently update world coordinates on Y-axis, namely: $Y_{w1}=Y_{mw1}$, $Y_{w2}=Y_{mw2}$. Finally refresh the canvas to redraw the graph to achieve the restrictive amplification.


a) Under Screen Coordinate System   b) Under World Coordinate System
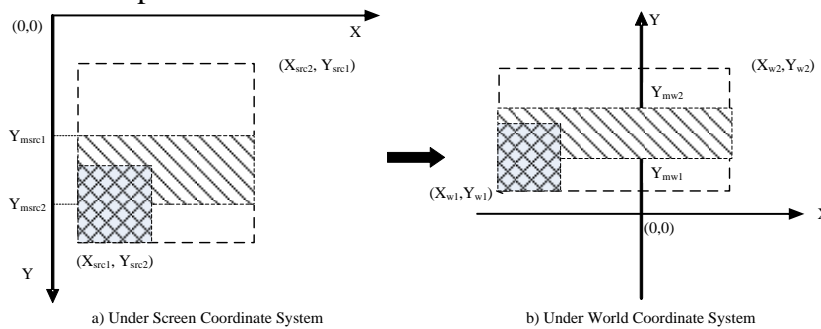
Figure 3 the Demo of Y-axis Restrictive Amplification Algorithm

4. The Implementation of Restrictive Amplification In Software

4.1 Rewrite the Class of the "CRectTracker".

As mentioned before, the restrictive amplification function required to generate a rubber band rectangle window in real time to display the current amplification region. And in the MFC, there is a standard class, namely "CRectTracker", whose object can generate this window in real time, as shown in Figure (4-a). However, this window is not equal to the window required by X/Y-axis restrictive amplification, as shown in Figure (4-b) and Figure (4-c). Therefore, there is a need to rewrite this class to change its functions.
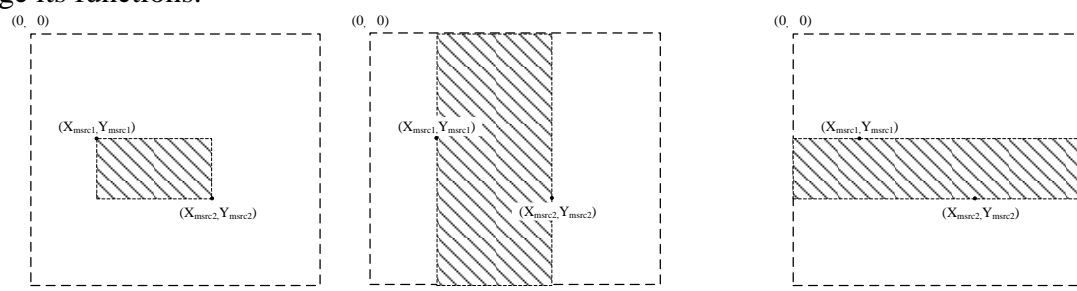
a) The Window of CRectTracker object generated   **b)** The Window required by X-axis restrictive amplification   **c)** The Window required by Y-axis restrictive amplification

Figure 4 the Demo of Window Comparison

Specific steps are as follows:

1) The subclass of CMyTracker inherit from the CRectTracker class. Add some member variables, as shown in table 1, into the subclass.

Table 1 Member variables information of the CMyTracker

Name	Type	Initial Value	Definition Purpose
m_rectParent	CRect	CRect(0,0,0,0)	Record the client screen coordinate of parent window.
m_bIfZoomX	bool	True	The false value represents restrictive amplification on the Y-axis, otherwise represents restrictive amplification on the X-axis.

2) Overload the function of "void OnChangedRect (const CRect& rectOld)" in the CMyTracker. When the rectangle is resized or moved, this function will be called by the MFC framework, therefore, to achieve the purpose of redraw the rectangle as shown in (4-b) and (4-c), need to override this function as follows:

```
Void CMyTracker::OnChangedRect(const CRect& rectOld)
{
If (!m_bIfZoomX)//Y
{
m_rect.left=m_rectParent.left;
m_rect.right=m_rectParent.right;
}
else//
{
m_rect.top=m_rectParent.top;
m_rect.bottom=m_rectParent.bottom;
}
}
```

4.2 Add Variables into the Canvas Class

Assume that the canvas class name for CCanvasView (the same below). Need to add four member variables, as shown in table 2, into the CCanvasView.

Table 2 Member variables information of the CCanvasView

Name	Type	Initial Value	Definition Purpose
m_enumMode	Enum_CVMode	CMode_Normal	Mark the current function model of the canvas.
m_rectClient	CRect	CRect(0,0,0,0)	Record the client screen coordinate of the current canvas window.
m_pTracker	CMyTracker*	NULL	Record the CMyTracker object, which is used to mark the restrictive amplification region selected by users.
m_DragStartPoint	CPoint	CPoint(0,0)	Record the screen coordinate of drag-start point when users drag the mouse.
m_DragStopPoint	CPoint	CPoint(0,0)	Record the screen coordinate of drag-current point when users drag the mouse.
m_bMLBDown	bool	False	Indicate whether the left mouse button pressed, used to distinguish drag or move the mouse.

In the above table, the enum type of Enum_CVMode gives modes supported by the canvas, defined as follows:

```
enum Enum_CVMode // Canvas support function mode
{
CMode_Normal,//[Normal mode],Can't do anything
CMode_Zoom_In_X,//[Restrictive amplification on the X-axis mode], Can amplify the graph on
the X-axis
CMode_Zoom_In_Y,// [Restrictive amplification on the Y-axis mode], Can amplify the graph on
the Y-axis
```

CMode_Zoom_In ,//[Zoom in mode, Can amplify the graph on the X-axis and on the Y-axis

CMode_Zoom_Out ,// [Zoom out mode], Can zoom out the graph on the X-axis and on the Y-axis

CMode_Drag //[Drag canvas mode, Can move the canvas background

};

In order to get the screen coordinates of the current canvas window, need to add the following code in the function of "void CCanvasView::OnInitialUpdate()":

{

GetClientRect(&m_rectClient);

}

In order to generate the "rubber band" class object, need to add the following code in the constructor function of "CCanvasView::CCanvasView ()":

{

CRect tempRect(10, 10, 50, 50);

m_pTracker=new   CMyTracker(&tempRect,   CRectTracker::dottedLine | CRectTracker:: resizeInside);

}

In order to prevent memory leaks, need to add the following code in the destructor function of "CCanvasView::~CCanvasView ()":

if(NULL!= m_pTracker)

{

delete m_pTracker;

m_pTracker=NULL;

}

4.3 Add the Member Function for Complete Amplification Function

Add the member function of "bool CCanvasView::ZoomRcetIntoScreen (CRect)", whose implementation process is shown in Figure 5. The incoming parameter of this function is screen coordinates of the amplification region.
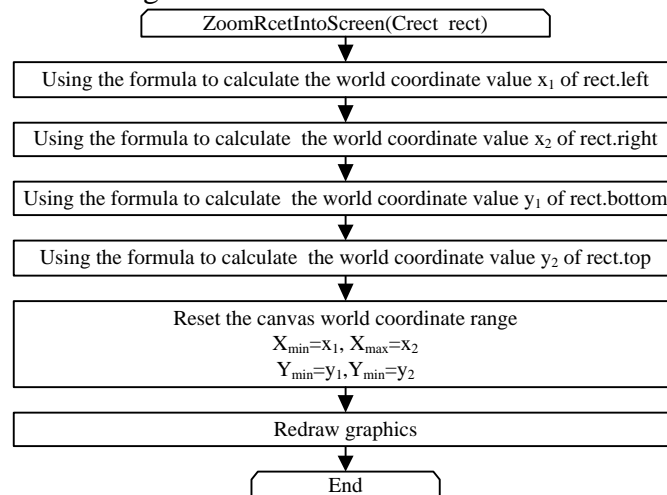
Figure 5 the Flowchart of ZoomRcetIntoScreen ()

4.4 Handle the Interaction of Users

To handle the interaction of users, need to do the following work:

1) Add the following code in the function of "void CCanvasView::OnL Button Down (UINT nFlags, CPoint point)", to record the screen coordinate of drag-start point when users drag the mouse:

{

m_bMLBDown=true;

m_DragStartPoint=m_DragStopPoint=point;

}

2) Add the following code in the function of "void CCanvasView::OnMouseMove (UINT nFlags, CPoint point)":

```
If (CMode_Zoom_In_X==m_enumMode||CMode_Zoom_In_Y==m_enumMode)
{
m_DragStopPoint=point;
If (m_DragStopPoint!=m_DragStartPoint && m_bMLBDown)//Users drag the mouse
{
CPoint pointStart,pointEnd;
If (CMode_Zoom_In_X==m_enumMode)
{
pointStart.x=m_DragStartPoint.x;
pointStart.y=m_rectClient.top;
pointEnd.x=m_DragStopPoint.x;
pointEnd.y=m_rectClient.bottom;
m_pMyTrackerRect->m_bIfZoomX=true;
}
else if(CMode_Zoom_In_Y==m_enumMode)
{
pointStart.x=m_rectClient.left;
pointStart.y=m_DragStartPoint.y;
pointEnd.x=m_rectClient.right;
pointEnd.y=m_DragStopPoint.y;
m_pMyTrackerRect->m_bIfZoomX=false;
}
CRect rect(pointStart,pointEnd);
m_pMyTrackerRect->m_rect=rect;
m_pMyTrackerRect->m_rectParent=m_rectClient;
m_pMyTrackerRect->TrackRubberBand(this,point,TRUE);
//If remove this statement, cannot amplify when select from bottom to top
m_pMyTrackerRect->m_rect.NormalizeRect();
//Amplify the rectangular of the m_pTracker-> m_rect to screen
ZoomRcetIntoScreen(m_pMyTrackerRect->m_rect);
m_bMLBDown=false;
}
}
```

3) Lay the "X-axis Restrictive Amplification Button" on the interface, and execute the following code when users click this button:

    m_enumMode= CMode_Zoom_In_X

4) Lay the "Y-axis Restrictive Amplification Button" on the interface, and execute the following code when users click this button:

    m_enumMode= CMode_Zoom_In_Y

5. Software Implementation Effect Test

The running results in well test interpretation software of applied the above ideas to design is as shown in figure 6 to 13. Among them, the figure 6~9 demonstrates the restrictive amplification under the rectangular coordinate system and the figure 10~13 demonstrates the restrictive amplification under the log-log coordinate system. It can be seen from above pictures that the restrictive amplification function can run reliable and the results are correct in the software realized by the above design idea.
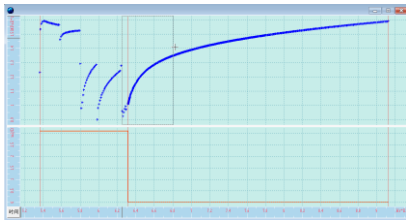
Figure 6 The Graph before X-axis Restrictive Amplification Under the Rectangular Coordinate System
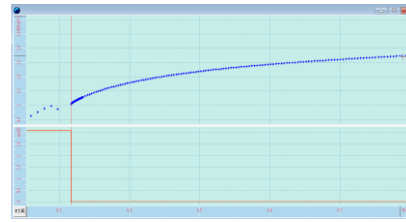

Figure 7 The Graph after X-axis Restrictive Amplification Under the Rectangular Coordinate System
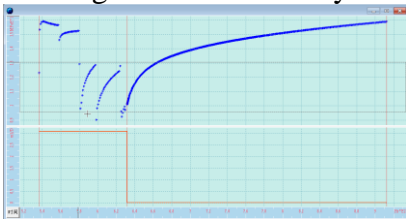

Figure 8 The Graph before Y-axis Restrictive Amplification Under the Rectangular Coordinate System
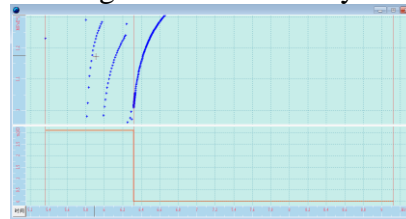

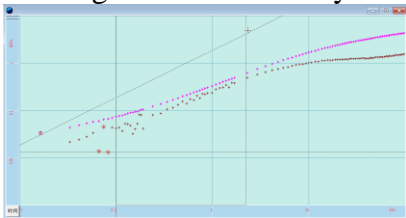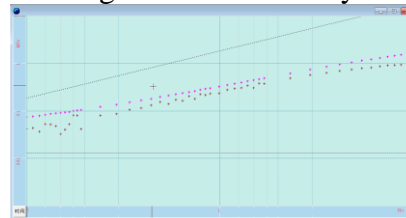Figure 9 The Graph after Y-axis Restrictive Amplification Under the Rectangular Coordinate System

Figure 10 The Graph before X-axis Restrictive Amplification Under the Log-log Coordinate System

Figure 11 The Graph after X-axis Restrictive Amplification Under the Log-log Coordinate System
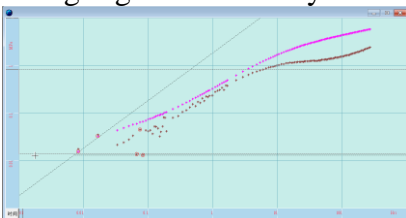

Figure 12 The Graph before Y-axis Restrictive Amplification Under the Log-log Coordinate System
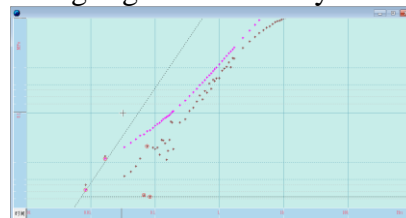

Figure 13 The Graph after Y-axis Restrictive Amplification Under the Log-log Coordinate System

6. Conclusion

In this paper, the following results have been achieved:

1) The transformation formula between world coordinate and screen coordinate under the rectangular, the semi-log and the log-log coordinate system has been given.

2) Combined the well test interpretation software functional requirements, the design thinking about the X/Y-axis restrictive amplification function and its algorithm implementation has been given.

3) Following the design ideas, the processes and procedures of software implementation in VS2010 environment has been given.

4) Taking the well test interpretation software for example, a detailed testing has been carried out. The test results show: the restrictive amplification function run normally and reliable in the software realized by the above design idea.

Acknowledgements

References

[1] Jia-en Lin , Shao-song Xu, Ning Zhuang etc.: Application of Well Testing Analysis Software for Multiple-well Systems, Well Testing, Vol. 7(1998), No.4, p.66-69.

[2] Yun-feng Tang: The Function and Application of Modern Well Test Interpretation Software DHC, Well Testing, Vol. 2(1993), No.1, p.74-77.

[3] Tang Yun-feng: The Introduction of Well Test Interpretation Software System IWTS, Well Testing, Vol. 4(1995), No.2, p.68-74.

[4] Gui-hua Wang, Xiao-ping Li, Jian-sheng Zhang, etc.: Software System Of Interpretation for Horizontally Fractured Well's Test-well, Journal Of DaQing Petroleum Institute, Vol.15(1991), No.3, p.92-97.

[5] Zhi-lin Yin: Comprehensive Software System For Reservoir Numerical Simulation, Petroleum Geology & Oilfield Development in Daqing, Vol.20(2001), No.3, p.50-52.

[6] Jia-qing Zhang, Jiang Dai, Kai-jun Jiang: The Functional Features and utilization of WTES 3.0 Comprehensive Well Testing Evaluation Software, Well Testing, Vol.9(2000), No.1, p.69-73.

[7] Xiu-jun Li: The Model of Well Test Analysis for Two-region Composite Reservoir and Study on Analysis Program(Master, Daqing Petroleum Institute, China 2009), p.51-52.

[8] A.C. Gringarten: Type-Curve Analysis: What It Can and Cannot Do, Journal of Petroleum Technology, Vol.39(1987), No.1, p.11-13.

[9] Ren-yuan Yu: Application of Modern Well Testing Interpretation Chart to Gas Well Testing Analysis, Natural Gas Industry, Vol.9(1989), No.4, p.38-42.

[10] Shang-qiao Chen, Hong-ming Liu: A Simple Zoom Method of Net, Journal of Geological Hazards and Environment Preservation, Vol.6(1995), No.4, p.59-63.

[11] Yuan-chen Li, Wei-qun Liu: Utilizing Pixel Duplication to Realize Local Amplification of Images, Journal of Taian Teachers College, Vol.24(2002), No.3, p.23-27.

[12] Li Liao: The Implementation of Partial Zoom in Data Visualization System, Computer Engineering and Applications, Vol.37(2002), No.16, p.244-246.

[13] Shu-qin Ji, Guo-feng Yu, Hai-zhen Zhao, etc.: The Discussion of Control Method of Graph in the Map Drawing Computer Software, Computer Engineering and Application, Vol.38(2003), No.11, p.91-105.

[14] Cheng-hui Yang, Jian-jun Meng: Realization of Data Collection Drawing and Zoom Based on Visual Basic, Computer Engineering and Design, Vol.29(2008), No.17, p.4600-4613.

[15] Hong-bin Cui, Guo-hai Qin, Wei Chang: Local Enlargement of Graphics Using OpenGL, Journal of Engineering Graphics, Vol.25(2005), No.6, p.58-62.

[16] Qi Yang, Xiao-zhen Tian: Research and Implementation of 3-D Perspective Algorithm Based on MFC, Microelectronics & Computer, Vol.25(2008), No.7, p.72-77.

[17] Yong Wang: Developing Computer Reading Graph Software with VB, Computers and Applied Chemistry, Vol.21(2004), No.3, p.477-480.

[18] Bo-tao Liu, Xin-Hai Wang, Fu-Xiang Zhang, etc.: The Algorithm Research and VS2010 Implementation of the Graph Zoom Function in the Log Coordinate System, Science Technology and Engineering, Vol.14(2014), No.4, p.205-216.