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Cognitive imaging in visual data-driven decision-support systems

- ◆ Foreword
- ◆ Cognitive imaging technologies
- ◆ SW and SH program systems
- ◆ Examples



ADASS2009

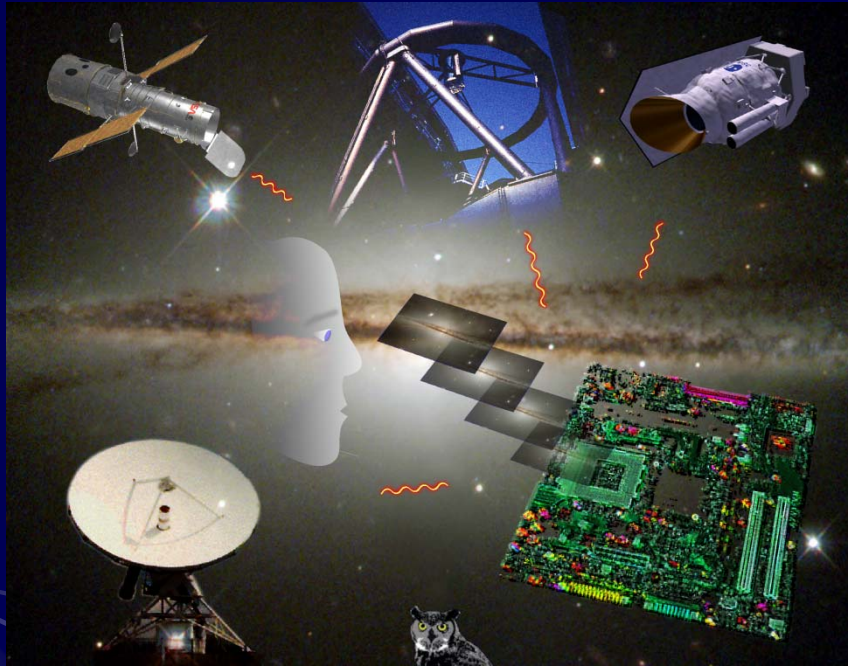
Foreword

Within data-driven types of decision-support systems (DSS, DDDSS), visual decision-support systems are those that try to inspire operator to find solution (decision) by producing visual representation of the data.

Traditional approaches, that utilize traditional scientific visualization techniques such as 2D and 3D plots, vector fields, surface maps etc, works well when subject to represent is relatively simply structured data, low-dimensional and weak interconnected. However, modern scientific experiments, as those in astrophysics observations, generate huge volumes of multidimensional complicated data.



Information big-bang first causes



New observational
techniques and
technologies



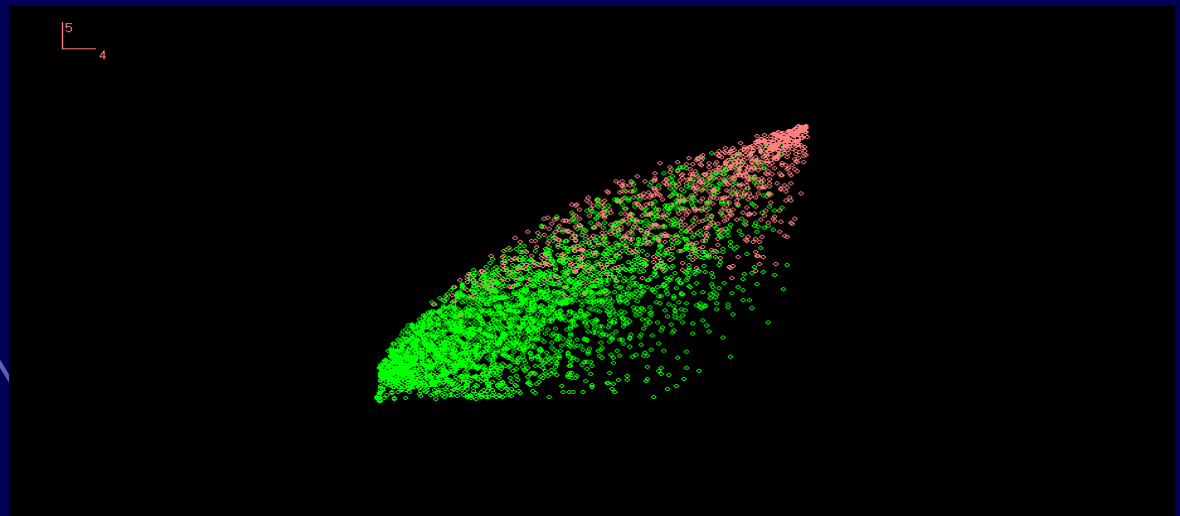
New informatics, computing
and communications
techniques and technologies



Cognitive visualization

More sophisticated approach for visualizing of big volumes of multidimensional data is that based on the cognitive machine graphics techniques, which, for example, are used in visualization system Space Walker (SW).

In contrast to illustrative ones, the cognitive images are aimed to make clear and evident some difficult scientific concepts and promote us with a new knowledge.



Cognitive visualization

It is known that the human intuition is activated in the case of the visualization of data. For the first time this was clearly demonstrated in the works Zenkin (1991), in which, in particular, it is shown as the observation of the cognitive means, connected with the properties of the natural numbers series, it made it possible to formulate and to prove a number of new theorems on the Warring problem.

At present questions of "obtaining", fixations, "mastering" of empirical experience are considered in such promising trend of information theory as engineering of knowledge. Specifically, in this direction actively are used the achievements of cognitive psychology, epistemology and mathematical means of relational algebra.



Cognitive visualization

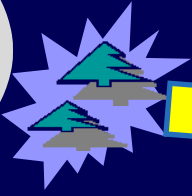
Experimental psychology has already sufficiently long ago developed and are investigated the effects of suggestion, and so the graphic, acoustic and tactile means of the stimulation of the consciousness of the human operator. In this sense the systems of cognitive machine drawing are only one additional subset of the interesting technical equipment, which generate new psychological phenomena.

The phenomenon of cognitive machine drawing, for the first time scientifically noted by Zenkin, consists of the generation on the screen of display of the special graphic representations, which create in the brain of human operator entertainment means.



Cognitive images generation

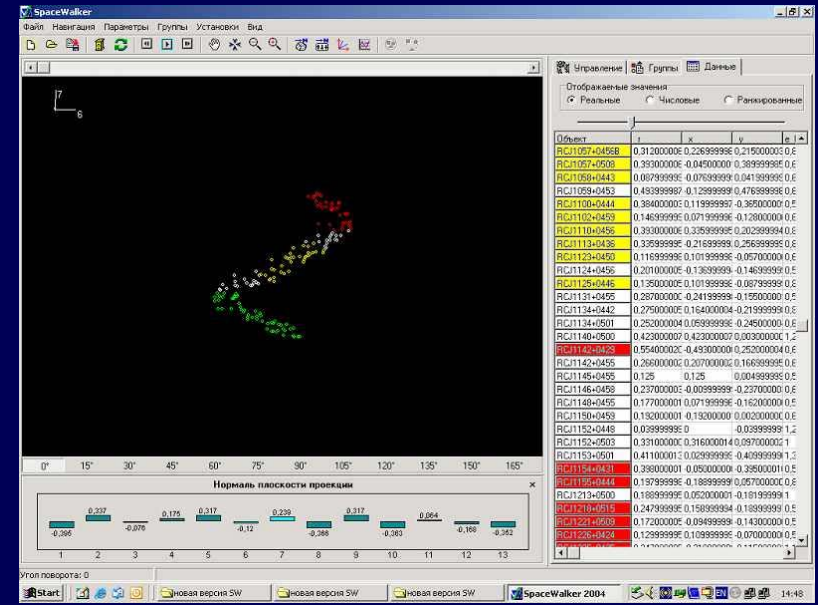
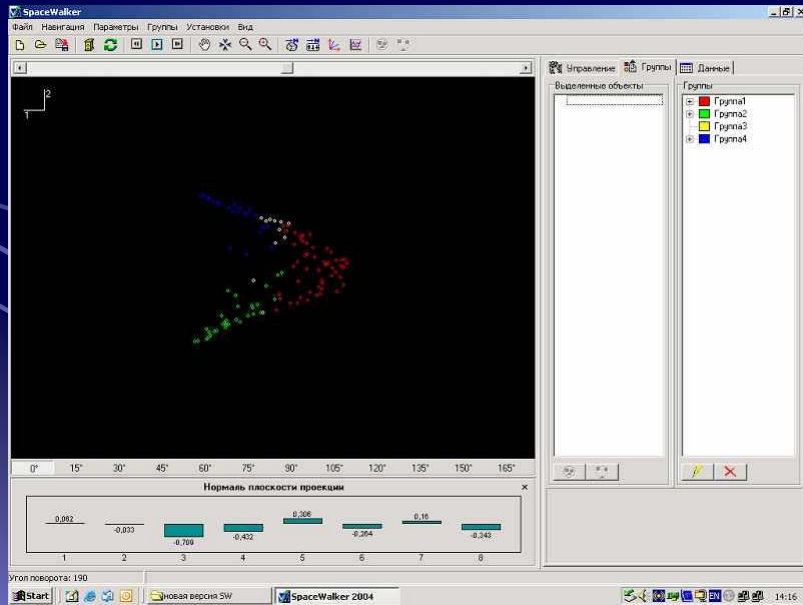
Cognitive graphics technique



noeza - process

noema - level 1

noema - level 2



Cognitive images generation

The essence of cognitive effect lies in the fact that man receives the moving projection as pseudo-three-dimensional object characterizing multidimensional means in the multidimensional space. Taking into account the fact that the user can easily change the direction of projection, its emotional possibilities can be easily begun to operate for the formation of cognitive multidimensional means.

Preliminary scaling is indicative along the axes with the aid of the ordinal statistician it ensures authenticity and robustness of this means (Gorohov, Vitkovskiy 1994).



Cognitive images generation

The possibility of the generation of the visual means of the multidimensional cloud of data is very important, since man cannot, examining the multidimensional tables of data see these multidimensional means.

The algorithms and the programs, which achieve a projection of this cloud to the two-dimensional hyperplane Q , which coincides with the plane of the display screen, are proposed for this. The organization of projection to plane Q lies in the fact that is constructed the coordinate system, attached to this plane. A change of orienting the plane Q is expressed as the values of the guides of cosines.



Cognitive images generation

Should be noted the striking property of the two-dimensional projection of multidimensional data on the display screen to cause in the brain of man of operator pseudo-three-dimensional means during the dynamic motion of data in the multidimensional phase space.

This fact involved the comfortable perception of multidimensional data by man. It is possible that the already existing procedures of the contemporary probability theory and mathematical statistics can give and already give the methods of cognitive visualization.



Space Walker system

Appropriate the cognitive pictures not only make evident and clear the sense of complex and difficult scientific concepts, but promote, - and not so very rarely, - a birth of a new knowledge.

On the basis of the cognitive graphics concept, we worked out the SW-system for visualization and analysis. It allows to train and to aggravate intuition of researcher, to raise his interest and motivation to the creative, scientific cognition, to realize process of dialogue with the very problems simultaneously.



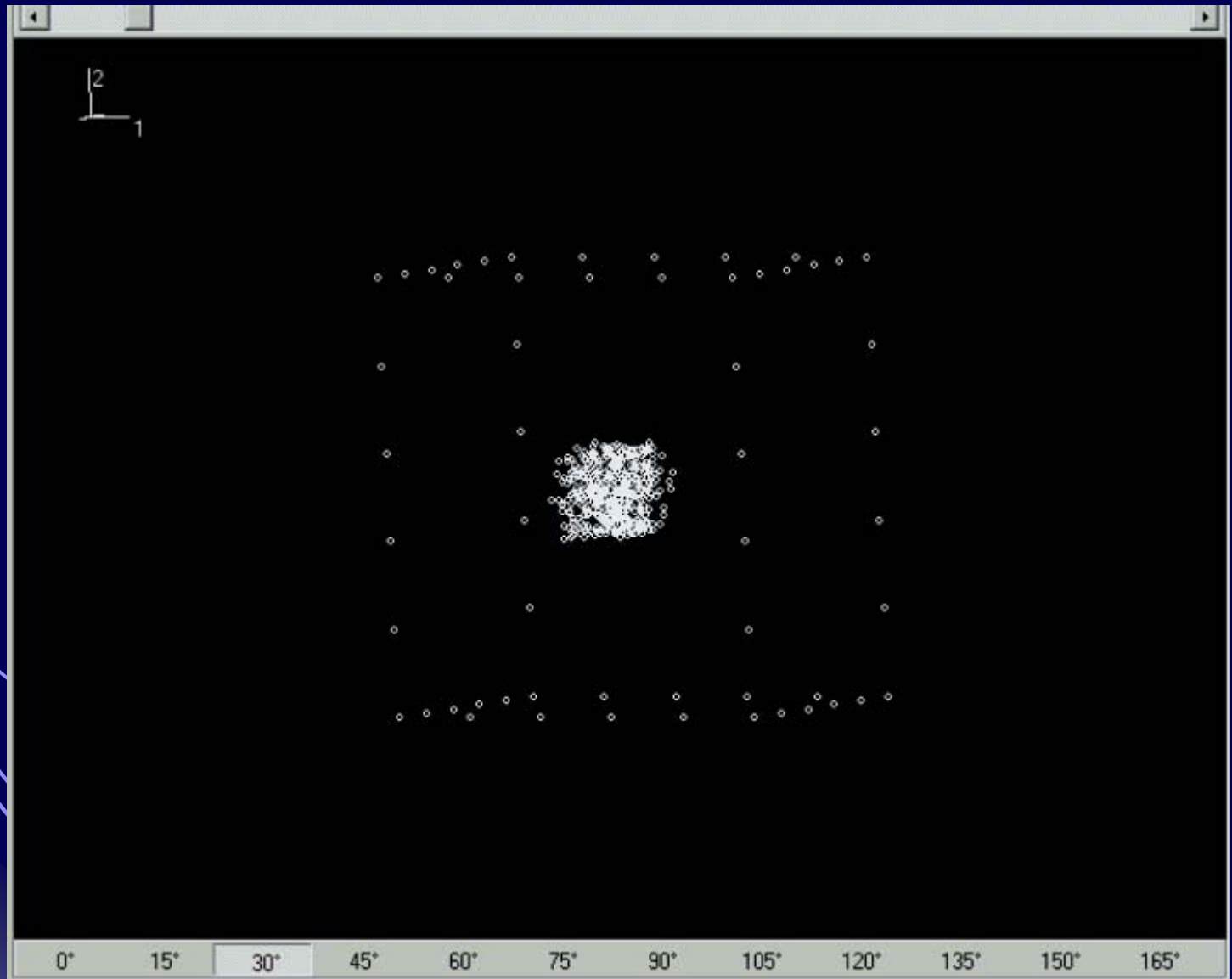
Space Walker system

If many objects are studied, then it is possible to present them in the form of cloud of points in the multidimensional parameters (indications) space. The configuration of this cloud bears extensive information about the observed objects.

The form of this multidimensional cloud characterizes the multidimensional connections between different parameters for the uniform objects. These connections are expressed in the form of multidimensional figures; the direction of tangents to them indicates nature and force of statistical connections. If initial objects are divided into different clusters (the most different possible classes), then this be reflected in the form of multidimensional means as its partition into the whimsical family of clouds.



SpaceWalker 3D image



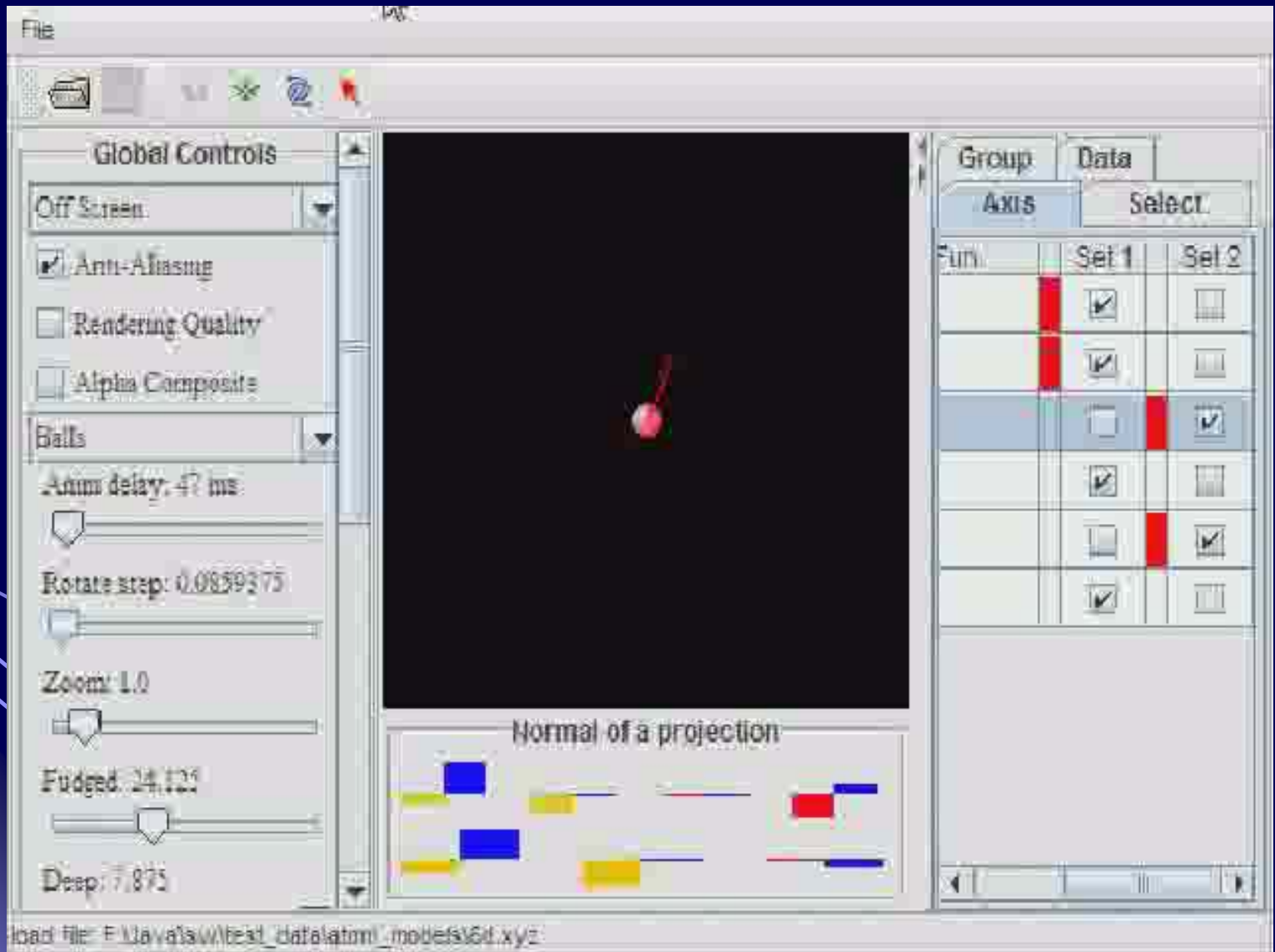
SpaceHedgehog system

The Space Hedgehog system is the next step in the cognitive means of the multidimensional data analyze. The technique and technology cognitive 6D visualization of the multidimensional data is developed on the basis of the cognitive visualization research and technology development.

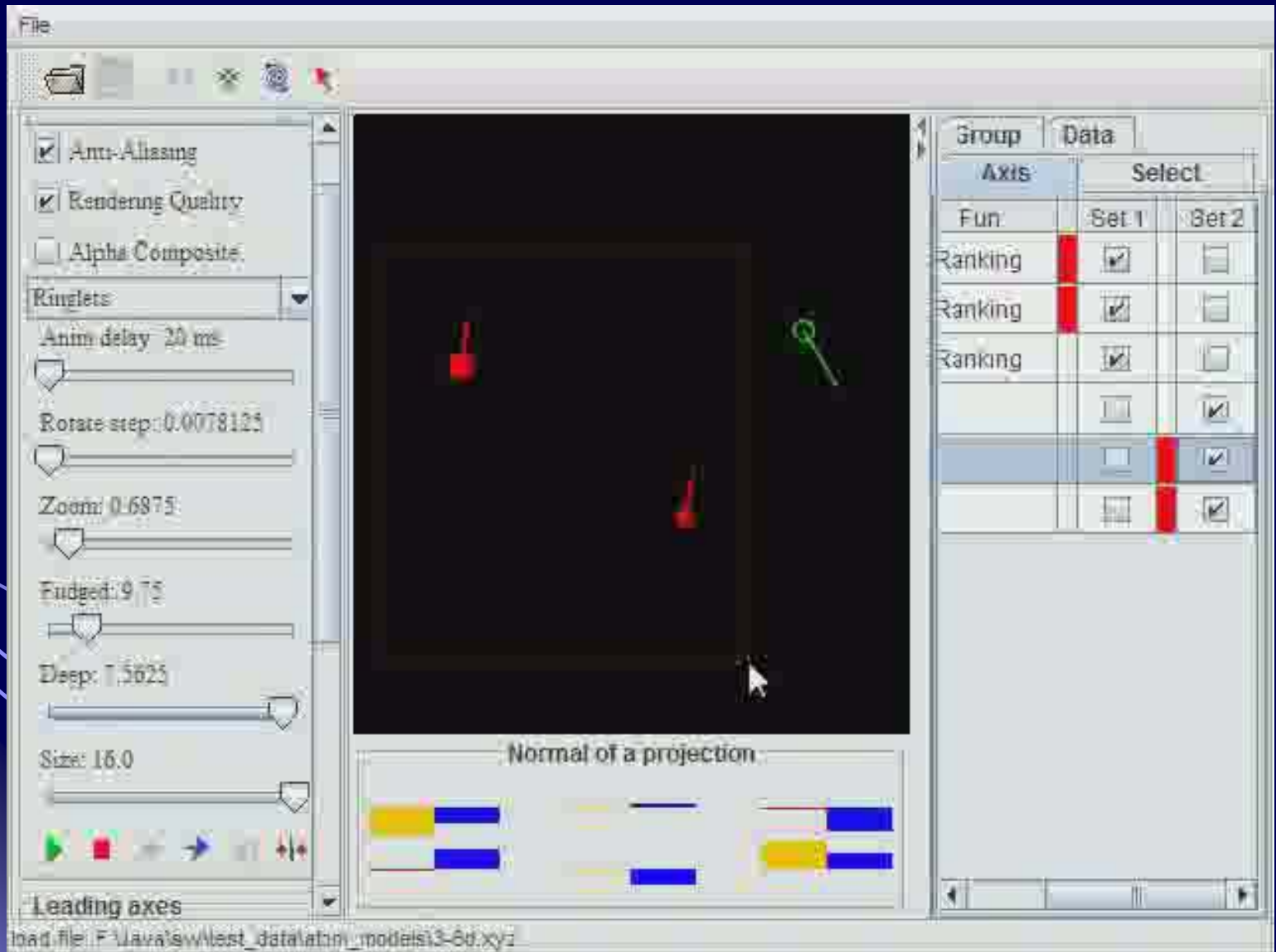
The Space Hedgehog system allows direct dynamic visualization of 6D objects. It is developed with use of experience of the program Space Walker creation and its applications.



3D vector image



SpaceWalker to SpaceHedgehog



SpaceHedgehog 6D image

The screenshot shows a Java application window with a title bar 'File'. The interface is divided into several sections:

- Global Controls:** A sidebar on the left containing various settings:
 - Off Screen: dropdown menu
 - Anti-Aliasing:
 - Rendering Quality:
 - Alpha Composite:
 - Ringlets: dropdown menu
 - Anim delay: 500 ms (slider)
 - Rotate step: 0.0546875 (slider)
 - Zoom: 1.0625 (slider)
 - Fudged: 1.125 (slider)
- 3D Viewport:** A central window displaying a 3D model of a hedgehog-like object with many sharp, white, needle-like protrusions on a dark, curved surface.
- Normal of a projection:** A diagram below the viewport showing several horizontal bars with colored segments (yellow, blue, red) representing different data series or projections.
- Table:** A table on the right side of the window with columns for 'Group', 'Data', and 'Select'. The 'Data' column is further divided into 'Set 1' and 'Set 2'. The 'Select' column contains checkboxes. The 'Group' column lists 'Axis' and 'Fun' (repeated 8 times). Red vertical bars are present in the 'Data' column for the first two 'Fun' rows and the sixth 'Fun' row.

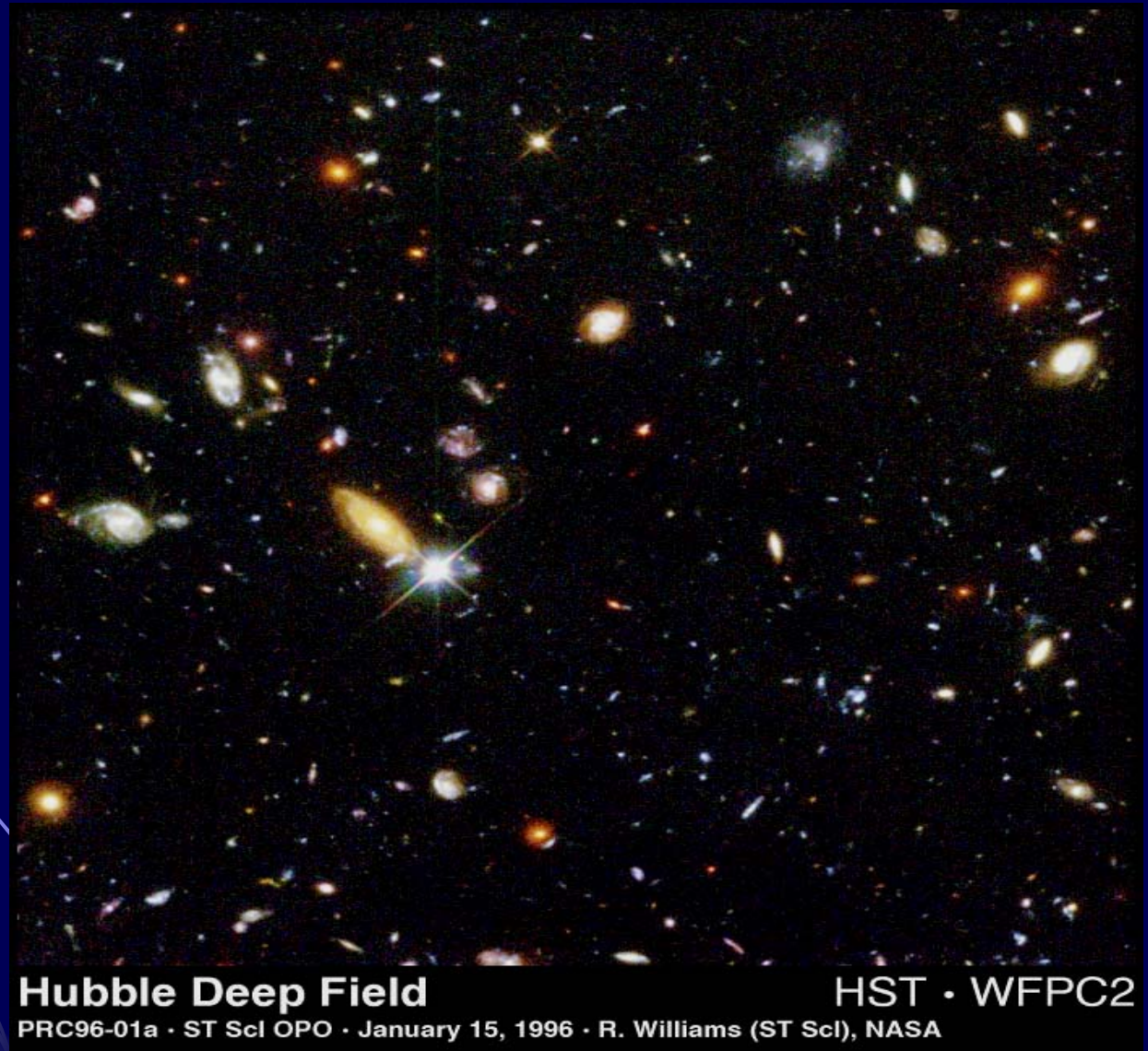
At the bottom of the window, the following text is visible: `load file: F:\Java\sw\test_data\poster\MRCaIASTRO2.csv`



Non-Cartesian image projection



Hubble Deep Field image



Hubble Deep Field

HST · WFPC2

PRC96-01a · ST ScI OPO · January 15, 1996 · R. Williams (ST ScI), NASA



Hubble Deep Field Catalogue

Microsoft Excel - HUDF_Catalog_Gorohov(2)

Файл Правка Вид Вставка Формат Сервис Данные Окно Справка Adobe PDF Введите вопрос

BA1

Цвет шрифта (Красный)

	A	B	C	D	E	F	G	H	I	J	K	L	M
1		NUMBER	X_IMAGE	Y_IMAGE	A	B	THETA	ELONGATION	ELLIPTICITY	b	b_er	MU_MAX	FLUX_RADIUS(50
2	1	1	5315,862	351,443	29,641	18,853	8,1	1,572	0,364	22,34	0	21,9	
3	2	2	5208,999	223,655	10,861	3,5	-21,9	3,103	0,678	27	0,03	23,95	
4	3	3	5252	248,921	5,328	2,368	60,6	2,25	0,555	28,05	0,05	23,45	
5	4	4	4828,016	226,964	1,029	0,878	-63,1	1,172	0,147	99	99	27,56	
6	5	5	4838,444	257,488	1,078	0,747	-77,8	1,443	0,307	99	99	23,91	
7	6	6	5200,642	291,508	2,588	2,435	-66,1	1,062	0,059	28,66	0,06	23,72	
8	7	7	4861,638	299,841	2,999	1,538	28,1	1,949	0,487	30,41	0,27	23,92	
9	8	8	5059,521	330,973	2,192	2,097	-86,7	1,045	0,043	28,05	0,03	22,86	
10	9	9	4757,181	318,13	2,211	0,997	46,3	2,217	0,549	99	99	99	
11	10	10	5106,159	340,069	4,183	2,576	-24,5	1,624	0,384	27,68	0,04	23,83	
12	11	11	4905,53	328,416	2,202	0,793	54,2	2,777	0,64	99	99	24,13	
13	12	12	5045,088	368,289	3,884	2,009	15,6	1,933	0,483	28,24	0,05	23,48	
14	13	13	5107,613	539,018	11,907	8,414	3,6	1,415	0,293	25,05	0,01	23,83	
15	14	14	4933,09	802,196	29,93	5,325	-82,7	5,62	0,822	24,18	0,01	23,23	
16	15	15	4695,034	582,484	9,681	6,063	38,4	1,597	0,374	28,24	0,08	23,83	
17	16	16	4638,38	469,266	1,904	1,744	-16,2	1,092	0,084	99	99	99	
18	17	17	4803,286	501,934	2,49	1,627	72,4	1,53	0,347	28,39	0,04	23,99	
19	18	18	5038,767	510,522	3,385	1,59	68,3	2,13	0,53	29	0,08	24,81	
20	19	19	4691,049	563,593	5,714	3,842	54,8	1,487	0,328	26,65	0,02	23,31	
21	20	20	4846,22	506,929	2,042	1,053	-2	1,939	0,484	32,7	1,41	24,29	
22	21	21	4702,29	566,656	6,538	3,578	19	1,827	0,453	26,85	0,02	22,99	
23	22	22	4790,305	553,165	3,966	3,465	71,2	1,144	0,126	26,92	0,02	23,66	
24	23	23	4922,474	549,178	2,471	1,363	40,5	1,813	0,449	29,17	0,07	24,7	
25	24	24	5405,027	623,086	7,499	2,52	-74,3	2,976	0,664	26,17	0,01	23,17	
26	25	25	4747,128	577,91	3,023	1,878	-61,7	1,61	0,379	28,37	0,04	23,74	
27	26	26	4728,929	584,098	2,931	2,111	-43,9	1,389	0,28	29,7	0,14	24,89	
28	27	27	4715,771	606,148	2,819	2,35	83,9	1,2	0,166	28,61	0,06	24,07	
29	28	28	5246,457	643,831	3,783	2,471	-16,7	1,531	0,347	27	0,02	23,7	
30	29	29	5211,499	683,476	5,614	3,495	61,9	1,606	0,378	26,51	0,02	23,55	
31	30	30	4868,17	644,009	2,619	1,434	89,1	1,827	0,453	29,24	0,07	24,35	
32	31	31	4856,506	644,653	2,934	1,221	-6,1	2,403	0,584	28,99	0,06	24,82	
33	32	32	4995,722	681,669	1,69	1,48	83,4	1,142	0,125	29,13	0,06	24,51	
34	33	33	5600,371	689,668	1,632	1,233	-80,9	1,323	0,244	29,76	0,1	24,26	

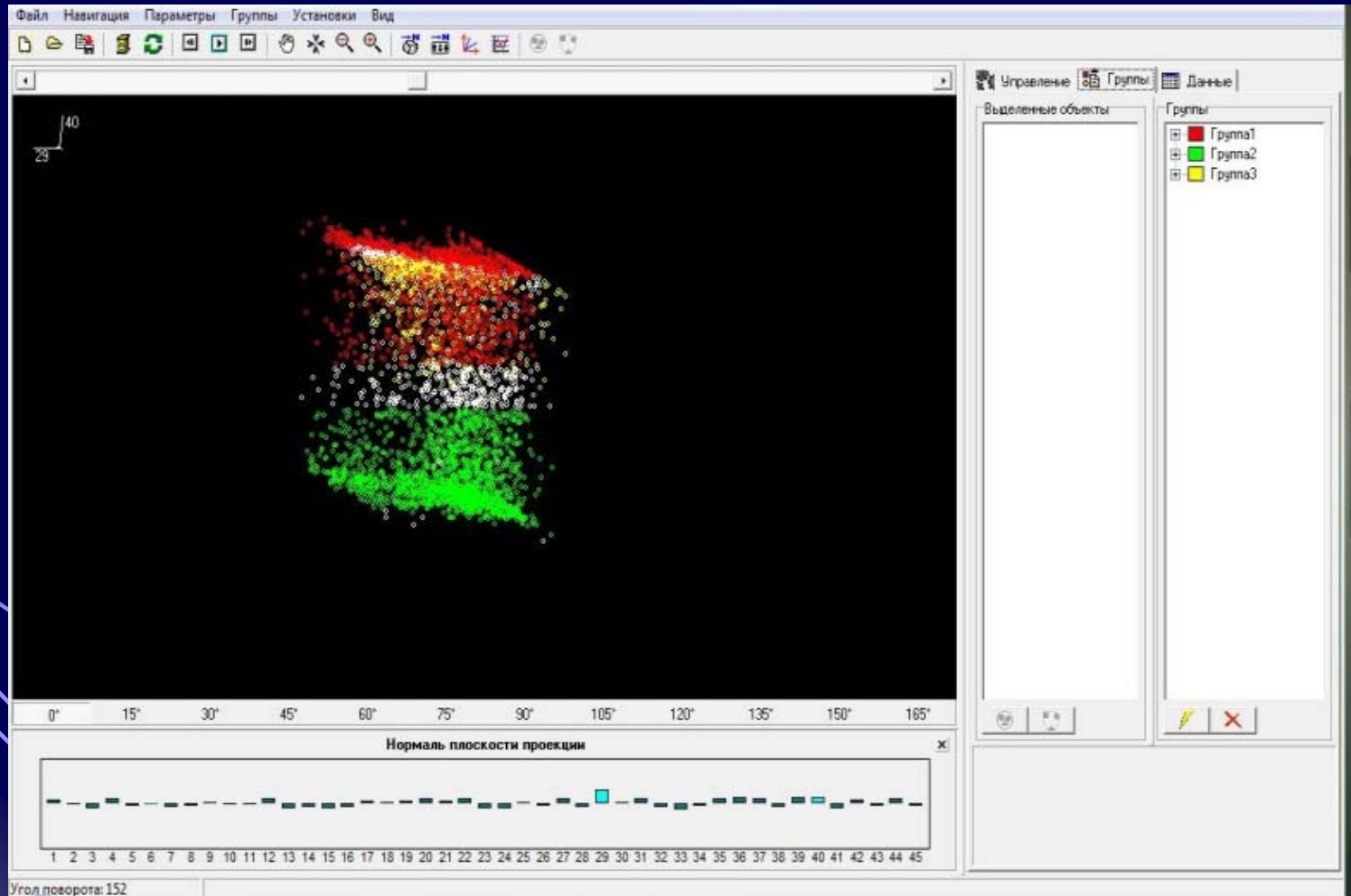
OutCat4Filter_sng5_mod_all

Готово

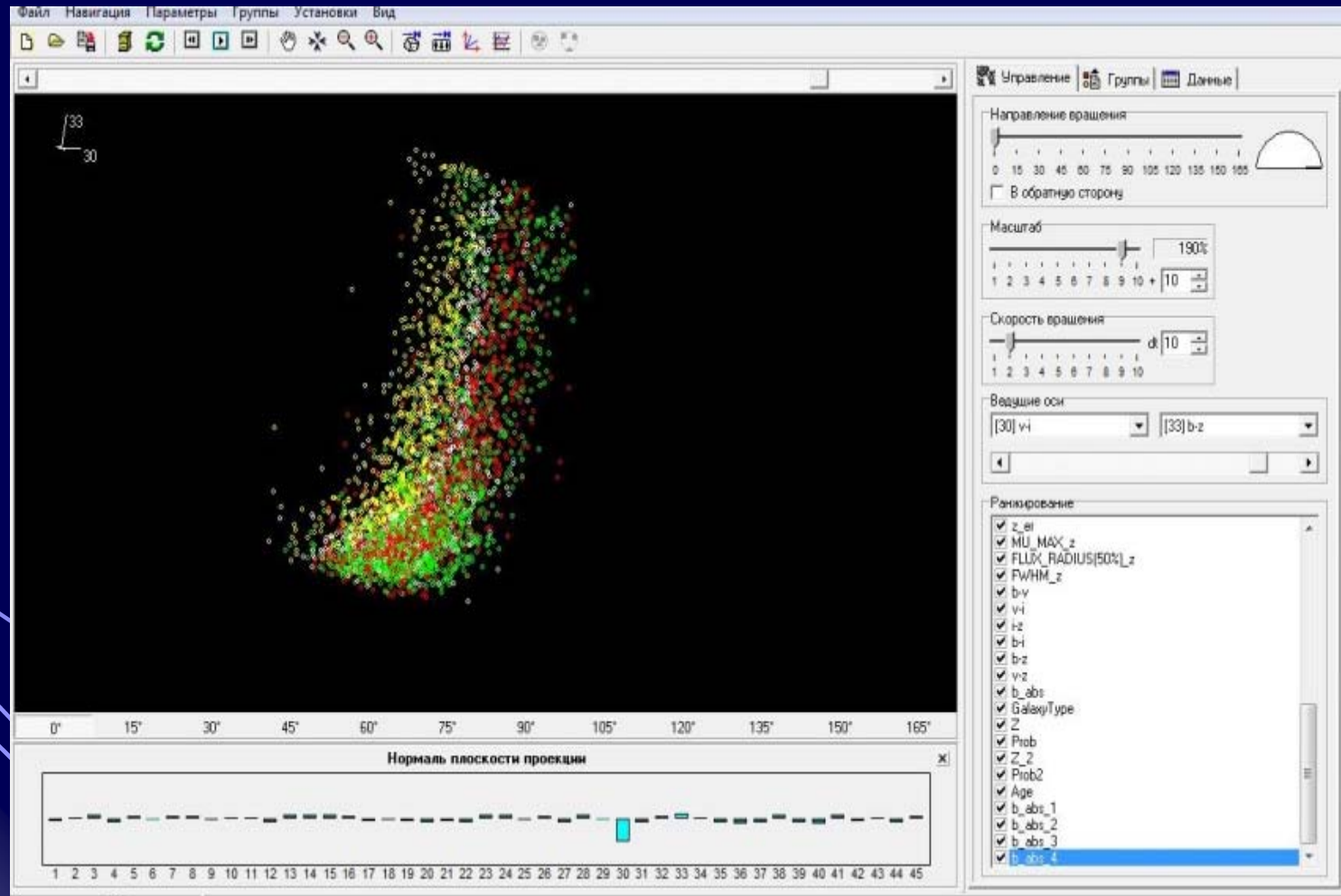
Пуск Sao-nb-word - Micro... MONONO16 - Micro... мои исследования... Microsoft Excel - ... 15:18



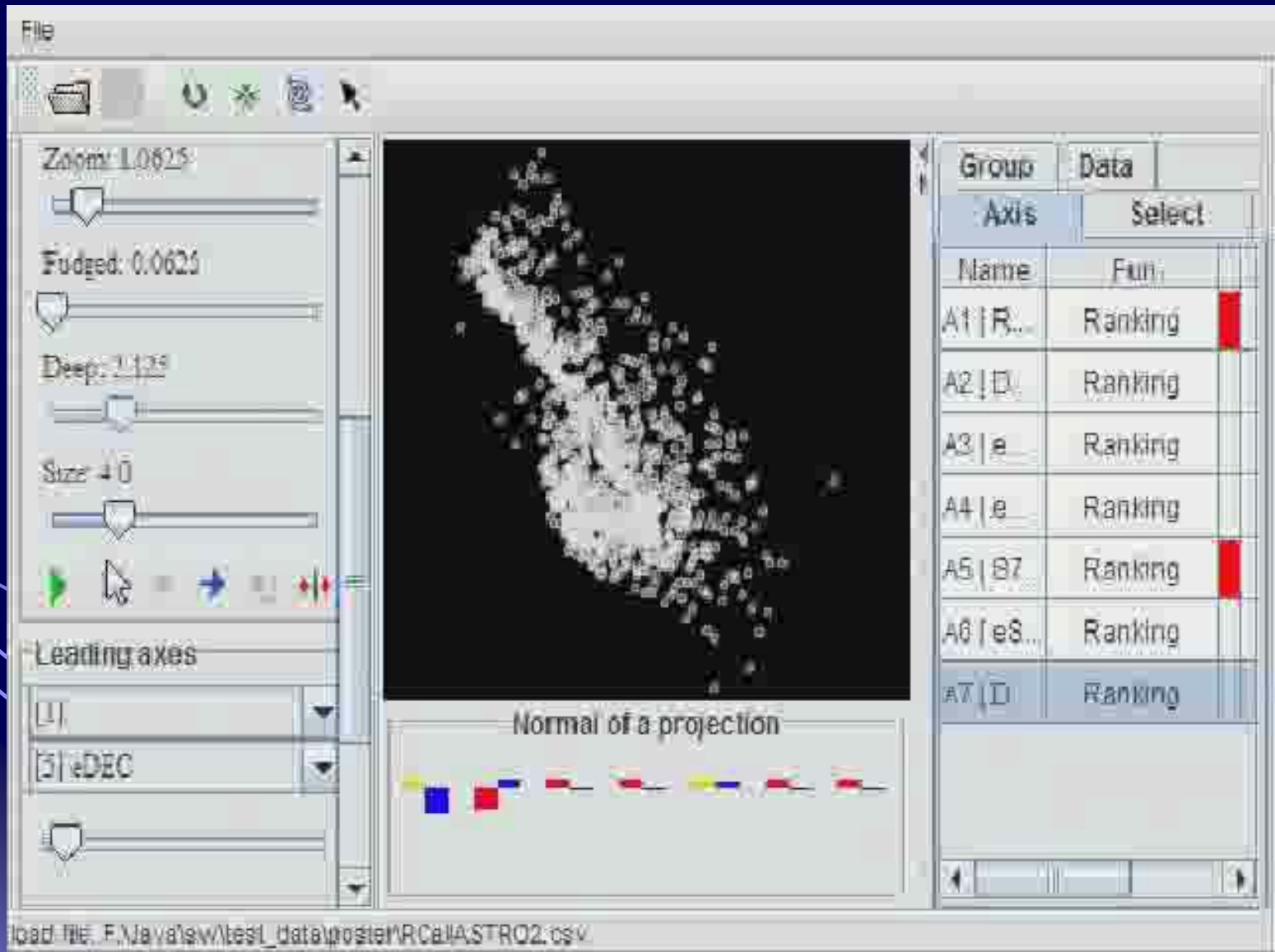
HDFC projection b-v, prob z



HDFC projection b-z,v-i



SW 3D image of RC catalogue



SH 6D image of RC catalogue

The screenshot displays a software application window with a central 3D visualization area. The visualization shows a dense, elongated point cloud of grey points, with a small red rectangular box highlighting a specific region. Below the 3D view, there is a diagram titled "Normal of a projection" showing several colored bars (yellow, blue, red) arranged in a pattern.

On the left side, there is a "Global Controls" panel with the following settings:

- Off Screen:
- Anti-Aliasing:
- Rendering Quality:
- Alpha Composite:
- Ringlets:
- Anim delay: 200 ms
- Rotate step: 0.1328125
- Zoom: 1.0625
- Fudged: 1.125

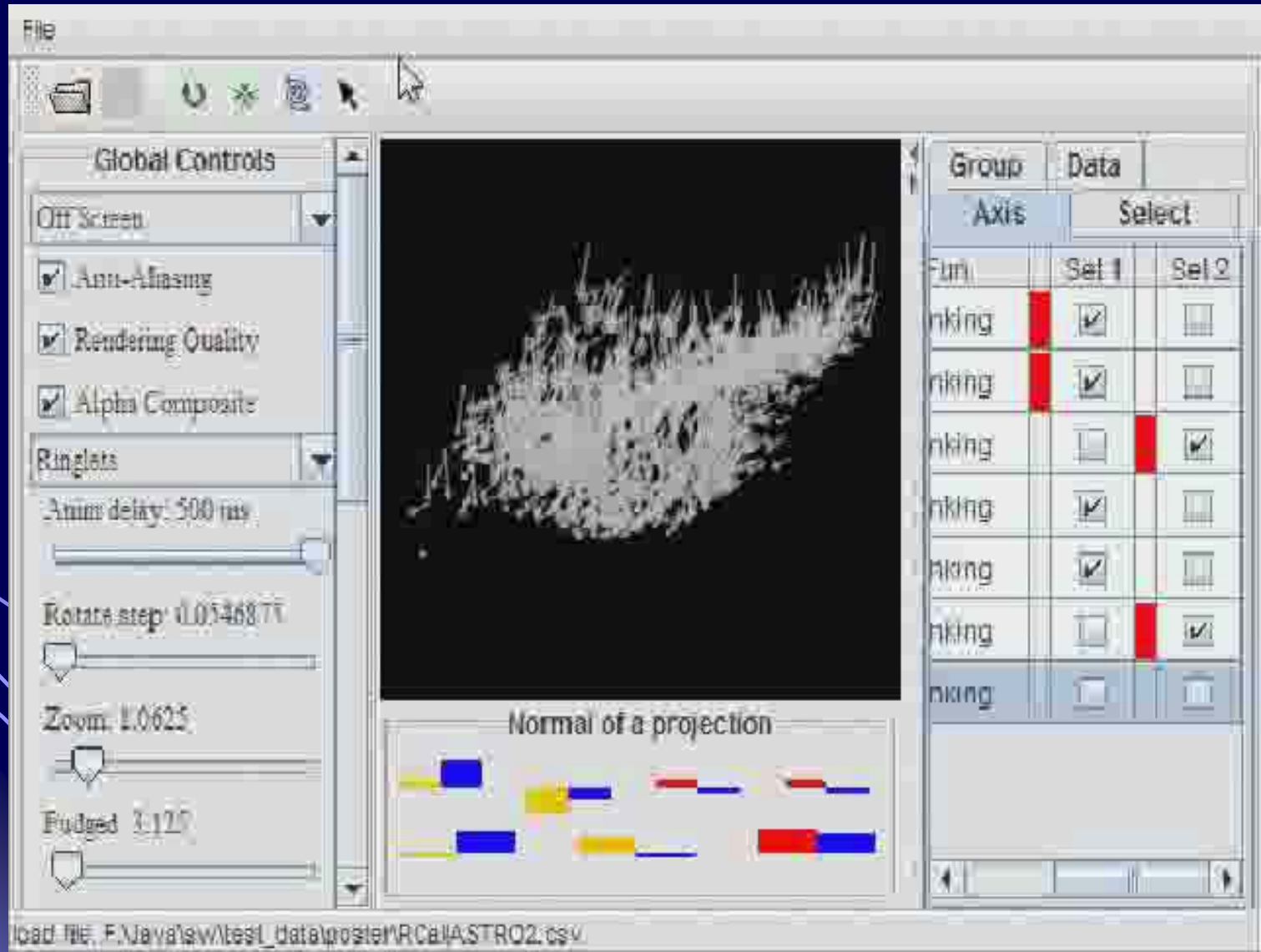
On the right side, there is a table with columns "Group", "Data", "Axis", and "Select". The "Axis" column has sub-columns "Set 1" and "Set 2". The "Select" column has sub-columns "Set 1" and "Set 2". The table contains several rows of data, with some cells containing checkboxes and red vertical bars.

Group	Data	Axis		Select	
		Set 1	Set 2	Set 1	Set 2
linking		<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
linking		<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
linking		<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
linking		<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
linking		<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
linking		<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
linking		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

At the bottom of the window, the file path is displayed: "load file: F:\Java\sw\test_data\poster\RCaIA\STRO2.csv".



SH 6D image of RC catalogue




The screenshot displays a software application window titled "File". The main view shows a 3D visualization of a star cluster, with a "Normal of a projection" diagram below it. The interface includes a "Global Controls" panel on the left and a data table on the right.

Global Controls

- Off Screen: [Dropdown]
- Anti-Aliasing
- Rendering Quality
- Alpha Composite
- Ringlets: [Dropdown]
- Anim delay: 500 ms [Slider]
- Rotate step: 0.0546877 [Slider]
- Zoom: 1.0625 [Slider]
- Fudged: 1.125 [Slider]

Normal of a projection



Data Table

Group	Data	
	Axis	Select
Fun.		
anking	[Red bar]	<input checked="" type="checkbox"/>
anking	[Red bar]	<input checked="" type="checkbox"/>
anking		[Red bar] <input checked="" type="checkbox"/>
anking		<input checked="" type="checkbox"/>
anking		<input checked="" type="checkbox"/>
anking		<input checked="" type="checkbox"/>
anking	[Red bar]	<input checked="" type="checkbox"/>
anking		<input type="checkbox"/>

load file: F:\Java\sw\test_data\poster\RCat\ASTRO2.csv



Conclusion

To sum up there is a list of potential advantages of cognitive DDDS systems compared to traditional DS systems:

1. Huge volumes of multidimensional data can be presented simultaneously.
2. The operator when dealing with cognitive image is not influenced by outer models, what in turn allow to use systems in case of a deep a priory uncertainty.
3. Existing data sets and archives can be used more successful.
4. Aesthetically attractive images and ability to operate on them like in multidimensional space allow researcher to utilize his knowledge in connection with boosted descriptive imagination.
5. This phenomena in turn can inspire intuition for non-trivial decision and solutions.



Thank you all

