

# What Can Woolz Bring To OME?

Bill Hill

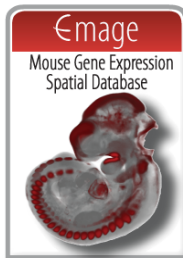
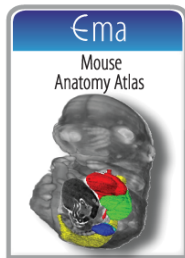
MRC Human Genetics Unit,  
MRC IGMM, University of Edinburgh,  
EH4 2XU, UK

[Bill.Hill@igmm.ed.ac.uk](mailto:Bill.Hill@igmm.ed.ac.uk)

June 18, 2012

# Context

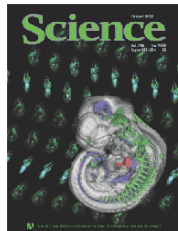
[www.emouseatlas.org](http://www.emouseatlas.org)



The e-Mouse Atlas Project



THE UNIVERSITY  
of EDINBURGH



# Overview

Woolz

IIP3D

Integration

# Woolz 1/5 - Origins (1980s)

FIP - Fast Interval  
Processor

Metaphase finding,  
cervical and lung  
cancer screening, ...

Hardware → Software



# Woolz 1/5 - Origins (1980s)

## FIP - Fast Interval Processor

Metaphase finding,  
cervical and lung  
cancer screening, ...

Hardware → Software

*Pattern Recognition* Vol. 14, No. 1 & 6, pp. 345-365, 1981.  
Printed in Great Britain.

0031-3201/81/070345-12 \$02.00/0  
Pergamon Press Ltd.  
© 1981 Pattern Recognition Society

### A FAST INTERVAL PROCESSOR

G. A. SHIPPEY, R. J. H. BAYLEY, A. S. J. FARROW, D. R. RUTOVITZ and J. H. TUCKER  
MRC Clinical and Population Cytogenetics Unit, Edinburgh, U.K.

*(Received for publication 22 December 1980)*

**Abstract** - The advent of high resolution Linear Image Sensors, and high p.t.f. stepping motors makes fast continuous scanning a practicable possibility. The FIP system under development at the MRC Edinburgh is intended to scan a conventional microscope slide in a time of 1 or 2 min with pixel size of 1  $\mu$ m.

The high pixel data rate (8 MHz peak) easily saturates most computer configurations, so special electronics is used to compress the data from a set of contiguous, above-threshold, pixels (i.e. 'intervals') into a set of interval parameters. These interval parameters, which include topological information, are then processed in one or more fast microprocessors to give object parameters from which the cells can then be classified according to some criterion.

The paper describes the hardware and software architecture, with comments on special buffering problems due to the continuous scan approach.

The linkage procedure used to reconstitute contiguous object descriptions is also described. This has to be very fast since the processing time available per object is only of the order of 1 ms.

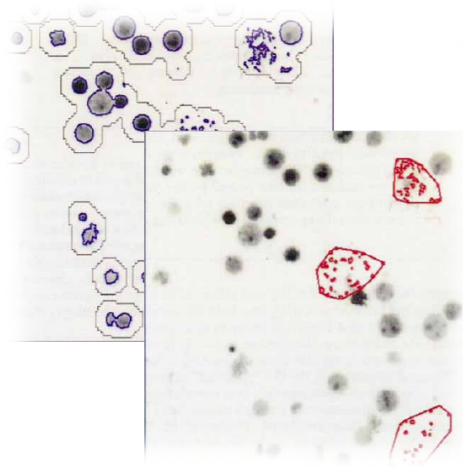
Interval Image sensor Stepping motor Auto-focus Metaphase Cervical smear Microprocessor

# Woolz 1/5 - Origins (1980s)

FIP - Fast Interval  
Processor

Metaphase finding,  
cervical and lung  
cancer screening, ...

Hardware → Software



# Woolz 1/5 - Origins (1980s)

FIP - Fast Interval  
Processor

Metaphase finding,  
cervical and lung  
cancer screening, ...

Hardware → Software

*Pattern Recognition Letters*  
Volume 3, Issue 2, March 1985, Pages 119-129

## Data structures for image processing in a C language and Unix environment<sup>☆</sup>

Jim Piper<sup>2</sup> and Denis Rutovitz<sup>2</sup>

<sup>2</sup>MRC Clinical and Population Cytogenetics Unit, Western General Hospital, Crewe Road, Edinburgh EH4 2XU, Scotland

Received 14 December 1983; revised 12 July 1984. Available online 19 May 2003.

### Abstract

A variety of single-address image, graphic, and image-operator data structures and a library of support subroutines have been implemented in the C programming language. These facilitate efficient and representation-independent procedure implementation, and have been used to construct a set of image processing tools in a Unix environment which make a flexible interactive image processing system.

**Keywords:** Image data; image domain; C language type structure; pointer variable; interactive image processing; shell programming

<sup>☆</sup>This work was supported entirely by the UK Medical Research Council.

# Woolz 2/5 - Domains and Values

object ← { type  
linkcount  
domain  
values  
properties

Object Types:

- ▶ Images
- ▶ Ancillary data (such as provenance)
- ▶ Annotation
- ▶ Boundaries, surface meshes and geometric models
- ▶ Conforming meshes
- ▶ Compound objects built from other objects
- ▶ Histograms and look up tables
- ▶ Transforms basis function, mesh, section

interval domains

memory mapped  
values

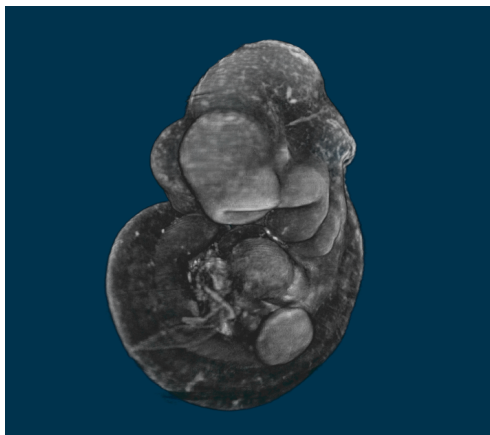


# Woolz 2/5 - Domains and Values

object ← { type  
linkcount  
domain  
values  
properties

interval domains

memory mapped  
values

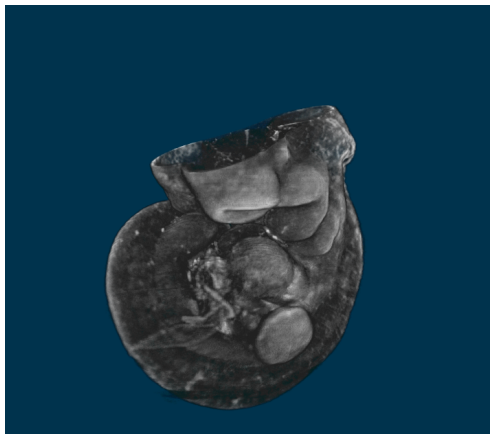


# Woolz 2/5 - Domains and Values

object ← { type  
linkcount  
domain  
values  
properties

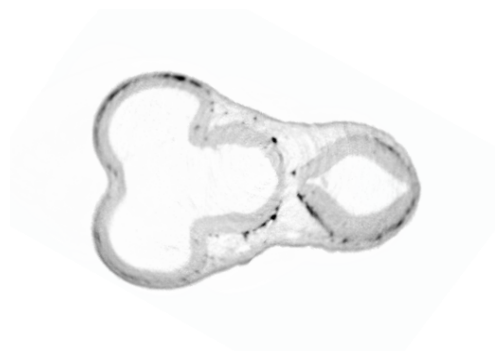
interval domains

memory mapped  
values



# Woolz 2/5 - Domains and Values

object ← { type  
linkcount  
domain  
values  
properties



interval domains

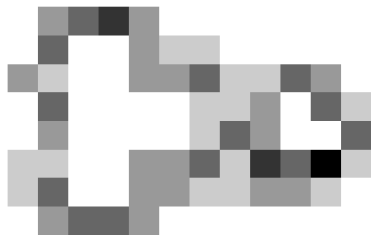
memory mapped  
values

# Woolz 2/5 - Domains and Values

object ← { type  
linkcount  
domain  
values  
properties

interval domains

memory mapped  
values



# Woolz 2/5 - Domains and Values

object ← { type  
linkcount  
domain  
values  
properties

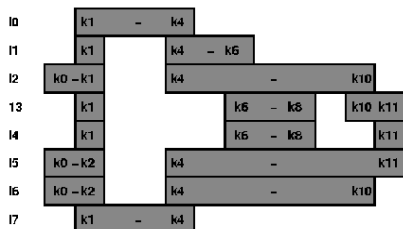
interval domains

memory mapped  
values



# Woolz 2/5 - Domains and Values

object ← { type  
linkcount  
domain  
values  
properties



interval domains

memory mapped  
values

# Woolz 2/5 - Domains and Values

object ← { type  
linkcount  
domain  
values  
properties

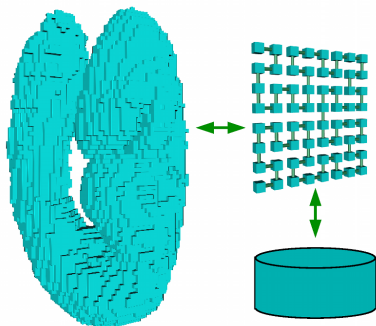
0 → 1-4  
1 → 1-1,4-6  
2 → 0-1,4-10  
3 → 1-1,6-8,10-11  
4 → 1-1,6-8,11-11  
5 → 0-2,4-11  
6 → 0-2,4-10  
7 → 1-4

interval domains

memory mapped  
values

# Woolz 2/5 - Domains and Values

object ← { type  
linkcount  
domain  
values  
properties

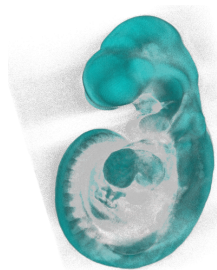


interval domains

memory mapped  
values



# Woolz 3/5 - Space and Time



Unsigned byte cuboid image 372x279x512  
(57MB),

Woolz object after threshold 7.7MB

Woolz domain after threshold 2.9MB

	time (ms)			
	Woolz	ITK	imagej	MATLAB
image threshold ( $\geq 32$ )	34	62	-	-
dilation (C26)	31 (C26)	-	407 (C8)	-
dilation (sphere $r=3$ )	120	3110	-	-
intersection	11	56	-	102

All times for 3.4 GHz Intel i7-2600 quad core CPU

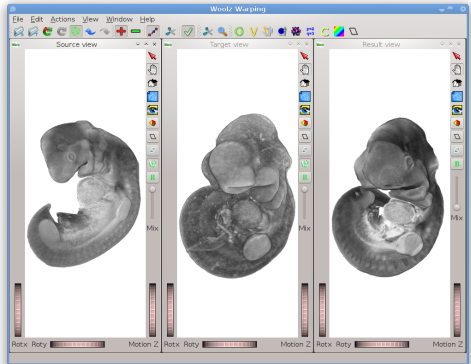
# Woolz 4/5 - Current Development

Large deformation  
spatial mapping.

External file format  
(R/W) support.

Higher dimensionality.

IIP3D support.



# Woolz 4/5 - Current Development

Large deformation  
spatial mapping.

External file format  
(R/W) support.

Higher dimensionality.

IIP3D support.

Amira Lattice (.am)	Microsoft Bitmap (.bmp)
Stanford Density (.den)	Netgen (.emt)
GIF (.gif)	ICS (.ics/.ids)
IPLab (.ipl)	JPEG (.jpg)
Pascal Frey's T Mesh (.mesh)	NIfTI (.nii)
Jonathan Shewchuk's T Mesh (.node)	Wavefront (.obj)
BioRad Confocal (.pic)	Riken PLY2 (.ply2)
PNM (.pgm)	Raw (.raw)
GRUMMP (.smesh)	GRUMMP (.vmesh)
Stereolithography (.stl)	Tagged Image (.tif)
Text (.txt)	Sunvision VFF (.vff)
SLC (.slc)	Visualization Toolkit (.vtk)

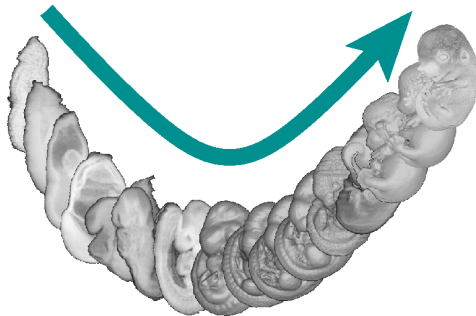
# Woolz 4/5 - Current Development

Large deformation  
spatial mapping.

External file format  
(R/W) support.

Higher dimensionality.

IIP3D support.



# Woolz 4/5 - Current Development

Large deformation  
spatial mapping.

External file format  
(R/W) support.

Higher dimensionality.

IIP3D support.

# Woolz 5/5 - The Code

Fast and space efficient image processing system

1/3 million lines of ANSI C

Self contained unless support for non Woolz file formats required

GNU GPL v2

<https://github.com/ma-tech/Woolz>

# IIP3D 1/7 - Overview

A Woolz server application based on IIPImage

Remote visualisation of large 3D images (3D images remain on server)

Tile based system for viewing arbitrary sections

Arbitrary number of channels per image

# IIP3D 2/5 - The IIP3D Protocol 1/2

Requests have 4 components

`http://a.b.c/cgi-bin/wziipsrv.fcgi? WLZ=/obj/a.wlz & DST=4 & QLT=50 & PTL=0,3`

Server address

Resource specifier

Parameters

Information request



# IIP3D 2/5 - The IIP3D Protocol 1/2

Requests have 4 components

`http://a.b.c/cgi-bin/wziipsrv.fcgi? WLZ=/obj/a.wlz & DST=4 & QLT=50 & PTL=0,3`

★ Server address

Resource specifier

Parameters

Information request

# IIP3D 2/5 - The IIP3D Protocol 1/2

Requests have 4 components

`http://a.b.c/cgi-bin/wziipsrv.fcgi? WLZ=/obj/a.wlz & DST=4 & QLT=50 & PTL=0,3`

Server address

★ Resource specifier

Parameters

Information request

# IIP3D 2/5 - The IIP3D Protocol 1/2

Requests have 4 components

`http://a.b.c/cgi-bin/wziipsrv.fcgi? WLZ=/obj/a.wlz & DST=4 & QLT=50 & PTL=0,3`

Server address

Resource specifier

★ Parameters

Information request

# IIP3D 2/5 - The IIP3D Protocol 1/2

Requests have 4 components

`http://a.b.c/cgi-bin/wziipsrv.fcgi? WLZ=/obj/a.wlz & DST=4 & QLT=50 & PTL-0,3`

Server address

Resource specifier

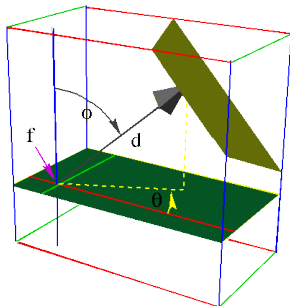
Parameters

★ Information request

# IIP3D 2/7 - The IIP3D Protocol 2/2

## IIP3D section transform specification

<b>DST</b>	-	distance of the sectioning plane
<b>FXP</b>	-	fixed point of the viewing section (1)
<b>FXT</b>	-	fixed point of the viewing section (2)
<b>MOD</b>	-	projection mode
<b>PIT</b>	-	pitch angle of the section plane
<b>ROL</b>	-	roll angle of the section plane
<b>SCL</b>	-	scale used in sectioning
<b>UPV</b>	-	up vector for the section plane
<b>YAW</b>	-	yaw angle of the section plane



# IIP3D 3/7 - The Server

Fork of IIPImage ([iipimage.sourceforge.net](http://iipimage.sourceforge.net))

Woolz compound objects can allow arbitrary number of 3D channels. Multiple channels composited at the server

Server caching of Woolz objects, section transforms and tiles

Memory mapped values significantly reduce cache requirements and give low latency access

Upper limit on object size determined by disk I/O

IIP3DProxy may also be used

# IIP3D 4/5 - The Client

Currently all IIP3D clients are browser based using AJAX

Client provides methods for user to select section transform and channels for display

Distance measurement

Mouse over information

# IIP3D 5/7 - Example Applications 1/4

aberlour.hgu.mrc.ac.uk/eAtlasViewer\_demo/application/visibleMale/visibleMale\_x8.php

File Edit View History Bookmarks Tools Help

http://aberlour.hgu.mrc.ac.uk/eAtlasViewer\_demo/application/visibleMale/visibleMale\_x8.php

QupZilla Most visited

http://aberlour.hgu.mrc.ac.uk/eAtlasViewer\_demo/application/visibleMale/visibleMale\_x8.php

8 X Visible Male Data Set (~ 135Gb)

Right-click over main image for context menu & more

dx: 400

magnification: 1.10

p: 90 y: 90 r: 90

Trans Sagit Front Fx Pt

reload image

Layers

Inference  Props

aberlour.hgu.mrc.ac.uk (192.107.168.130)



# IIP3D 5/7 - Example Applications 2/4

www.emouseatlas.org/eAtlasViewer\_ema/application/ema/wiz/EMA80.php

File Edit View History Bookmarks Tools Help

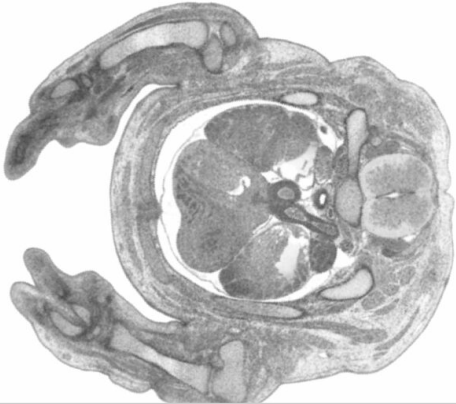
http://www.emouseatlas.org/eAtlasViewer\_ema/application/ema/wiz/EMA80.php

QupZilla Most visited

http://www.emouseatlas... x

3D Model (EMA:80): TS23(15 dpc)

right-click: over main image for context menu



p: 0 y: 0 r: 170

Trans Sagit Front Fx Pt

reload image

magnification: 1.2

dst: 0

www.emouseatlas.org (193.63.65.32)

The image shows a web browser window displaying a 3D model of a mouse embryo. The browser's address bar shows the URL 'http://www.emouseatlas.org/eAtlasViewer\_ema/application/ema/wiz/EMA80.php'. The page title is '3D Model (EMA:80): TS23(15 dpc)'. On the left side, there is a control panel with a small thumbnail of the embryo, a text box with instructions 'right-click: over main image for context menu', a larger 3D model of the embryo with a green horizontal plane, and several sliders and buttons for navigation and zooming. The sliders are labeled 'p: 0 y: 0 r: 170', 'magnification: 1.2', and 'dst: 0'. The buttons are labeled 'Trans', 'Sagit', 'Front', 'Fx Pt', and 'reload image'. The main area of the browser shows a large, detailed 3D model of the mouse embryo, showing internal organs and skeletal structure. The browser's status bar at the bottom shows the URL 'www.emouseatlas.org (193.63.65.32)'.

# IIP3D 5/7 - Example Applications 3/4

aberlour.hgu.mrc.ac.uk/eAtlasViewer\_demo/application/hudsen/CS17.php

File Edit View History Bookmarks Tools Help

http://aberlour.hgu.mrc.ac.uk/eAtlasViewer\_demo/application/hudsen/CS17.php

QupZilla Most visited

http://aberlour.hgu.mrc.... x

Electronic Atlas of the Developing Human Brain CS17

HUDSEN

Right-click over main image for context menu & more

dst: 0

magnification: 1:1

p: 90 y: 90 r: 90

Trans Sagt Front Fi Pt

reload image

Layers

reference Props

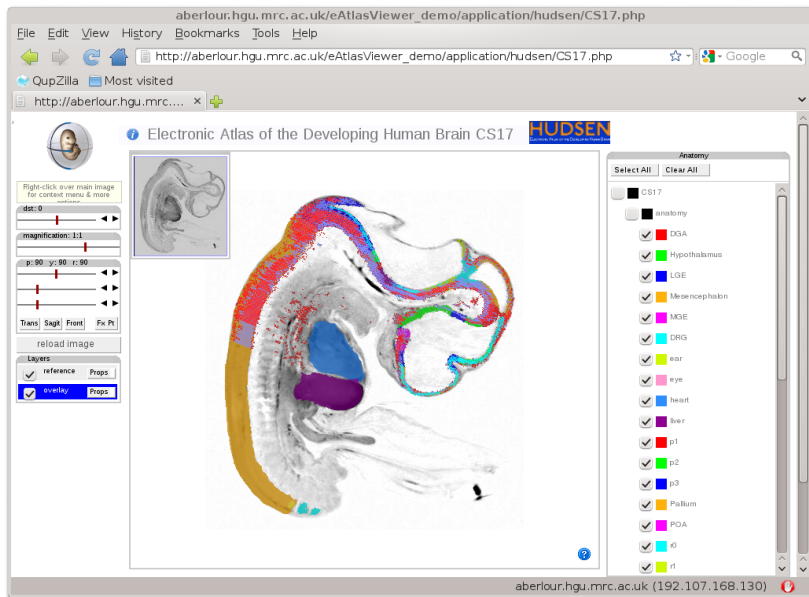
overlay Props

Anatomy

Select All Clear All

CS17

- anatomy
- DGA
- Hypothalamus
- LGE
- Midbrain
- M3E
- DRG
- ear
- eye
- heart
- liver
- p1
- p2
- p3
- Pallidum
- POA
- i0
- r1



aberlour.hgu.mrc.ac.uk (192.107.168.130)

# IIP3D 5/7 - Example Applications 4/5

Adult Brain Stack

File Edit View History Bookmarks Tools Help

http://www.virtualflybrain.org/site/stacks/index.htm

QupZilla Most visited

Virtual Fly Brain: Adult Br... x

## Virtual Fly Brain: Adult Brain Stack

Your trail: [The VFB Site](#) > [Stacks](#) > [Adult Brain Stack](#)

The VFB Site Tools Stacks Screen Resolution

magnification: 1.1

dist: 0

p: 0 y: 0 r: 0

Front Horiz Sagt Fx Pt

reload image

Anatomy Tree and Search

Clear all

- adult brain centre
- adult subesophageal ganglion centre
- supraesophageal ganglion centre
- adult antennal lobe centre
- adult central complex centre
- central body centre
- ellipsoid body centre
- fan-shaped body centre
- nodulus centre
- protocerebral bridge centre
- adult mushroom body centre
- inferior neuropile centre
- anterior centre

Stack info: [full info](#)

Template data by Arnim Jenett (Janelia Farm Research Campus), Kazunori Shinomiya and Kei Ito (Tokyo University)

Annotation for Selected Node [Right/ctrl click for queries](#)

www.virtualflybrain.org (129.215.33.184)

# IIP3D 6/7 - Current Development

Client GUI

WebGL in client

Morphological  
Operations

Image value  
remapping

Higher dimensionality.

# IIP3D 6/7 - Current Development

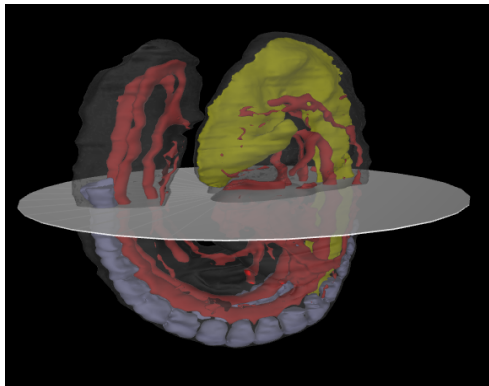
Client GUI

WebGL in client

Morphological  
Operations

Image value  
remapping

Higher dimensionality.



# IIP3D 6/7 - Current Development

Client GUI

WebGL in client

Morphological  
Operations

Image value  
remapping

Higher dimensionality.

```
SEL=diff(dilation(erosion(threshold(0,250,It),3),3),2),0,255,255,255
```



# IIP3D 6/7 - Current Development

Client GUI

WebGL in client

Morphological  
Operations

Image value  
remapping

Higher dimensionality.

# IIP3D 7/7 - The Code

C/C++

GNU GPL v2

<https://github.com/ma-tech/WlzIIPsrv>



# Integration of IIP3D, OME and Woolz 1/3

## Benefits for OMERO

- Mouse Atlas use cases

- Interactive remote visualisation of large (GB/TB) 3D images

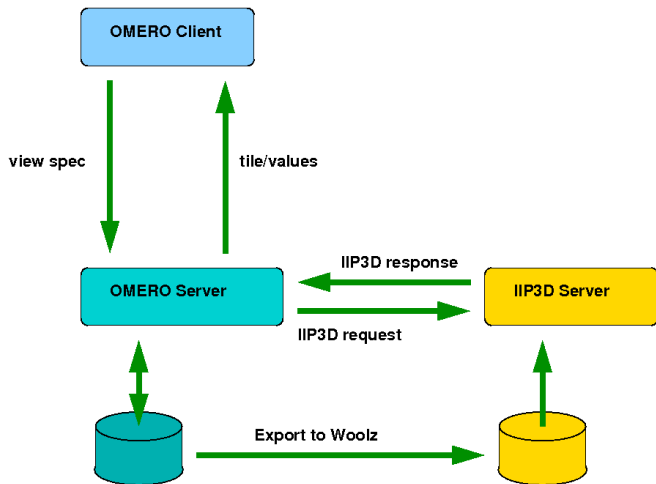
## Benefits for EMAP/EMAGE

- Image management

- Remote image annotation

# Integration of IIP3D, OME and Woolz 2/3

A possible model for loose integration



# Integration of IIP3D, OME and Woolz 3/3

## Additions to OME/OMERO

- Section transforms

- Export to Woolz

- Image origin

- Forward tiles/images

## Additions to IIP3D/Woolz

- 5D (ND?) images

- ?

# Summary

IIP3D can bring remote access to large 3D images to OMERO

Simple loosely coupled integration may be possible at expense of data duplication.

# Acknowledgements

- ▶ Zsolt Husz
- ▶ Richard Baldock
- ▶ IIPImage (<http://iipimage.sourceforge.net>)
- ▶ EMAGE & EMAP (<http://www.emouseatlas.org>)
- ▶ Hudson (<http://www.hudsen.org/>)
- ▶ Virtual Fly Brain (<http://www.virtualflybrain.org>)

# Additional - IIP3D Commands

## IIP3D commands that extend IIP specification

- DST** - distance of the sectioning plane
- FXP** - fixed point of the viewing section (1)
- FXT** - fixed point of the viewing section (2)
- MAP** - colour or grey value mapping
- MOD** - projection mode
- PAB** - query point absolute object coordinates
- PIT** - pitch angle of the section plane
- PRL** - query point relative in tile coordinates
- PTL** - retrieve tile as a PNG image
- ROL** - roll angle of the section plane
- SCL** - scale used in sectioning
- SEL** - select a component of a compound object
- UPV** - up vector for the section plane
- WLZ** - the Woolz object
- YAW** - yaw angle of the section plane

# Additional - IIP3D queries

## IIP3D queries that extend IIP specification

- Wlz-3d-bounding-box**
  - Wlz-coordinate-3D**
  - Wlz-distance-range**
  - Wlz-foreground-objects**
  - Wlz-grey-stats**
  - Wlz-grey-value**
  - Wlz-n-components**
  - Wlz-sectioning-angles**
  - Wlz-transformed-3d-bounding-box**
  - Wlz-transformed-coordinate-3d**
  - Wlz-true-voxel-size**
  - Wlz-volume**
- bounding box of the Woolz object
  - 3D object coordinates defined in 2D **PRL** command
  - range of section plane distance within the Woolz object
  - components of compound object at a query point
  - simple statistics of the Woolz object image values
  - object value at a query point
  - number of components in the compound object
  - section angles in degrees (pitch, yaw and roll)
  - bounding box of the Woolz object after section transform
  - display coordinates and displacement from the section plane of given coordinate
  - voxel size of the Woolz object
  - volume of the Woolz object in voxels

# Additional - IIP3D Examples

IIP3D (formerly WizIIP) is a protocol for delivering image tiles corresponding to a virtual section cut at any orientation through a volumetric image. The implementation includes a server, configured as a fast-cgi module, and an Ajax/javascript viewer to provide a novel fast method to access large 3D volumetric data sets. We especially target biological or medical imaging 3D images and atlases. The mechanism of browsing is similar to Google maps, but instead of a 2D map a 3D volumetric data is visualised.

The IIP3D server extends the IIP [1] protocol and provides a standard for visualising 3D and the web based client server architecture of IIP3D Viewer and IIP3D Server provides an alternative solution to the 3D atlas model viewing offered by the [JAtlasViewer](#).

The IIP3D server runs on a compute-server as a standalone image- or combined web and image server. The web server (e.g. apache2) forwards image requests using the IIP3D and extended IIP protocol. The IIP3DProxy allows switching requests between several image servers. This is especially useful if the web server is on the public internet, while the image servers are on a private network. IIP3DProxy allows a single access point to the image servers.

More information of the IIP3D can be found in our Technical report [2] and the publication [3]. Another publication is currently under review.

A number of example interfaces linked to the IIP3D server are linked below and provide access to image volumes up to 135GB. Older demonstrators associated with [3] are also available: [Old Demos](#).

1. [eMouseAtlas E14.5 mouse embryo](#) reconstruction. Standard model interface with measurement options.
2. [Large mouse embryo model](#) (30GB) from [embryoimaging.org](#)
3. [Waxholm space adult mouse brain model](#) - multiple overlaid image volumes with anatomy. Data from [INCF](#).
4. [Visible Human Dataset](#) (18GB).
5. [Large volume \(135GB\)](#) colour image constructed as 8 x visible human dataset.
6. [Human embryo view](#) showing anatomy and gene-expression overlay from the [HUDSEN](#) database.

www.emouseatlas.org (193.63.65.32)