Are callipers obsolete?

A novel 3D scanning technology to measure subcutaneous tumour volume

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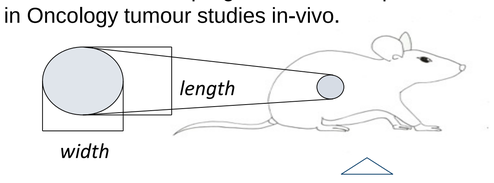
Background

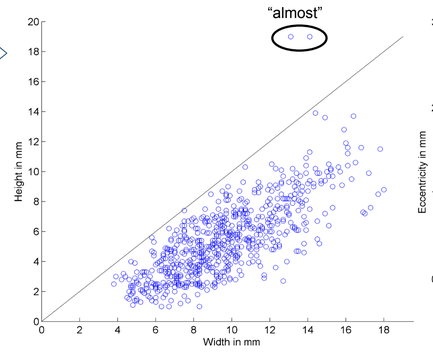
Why do we measure tumour volume?

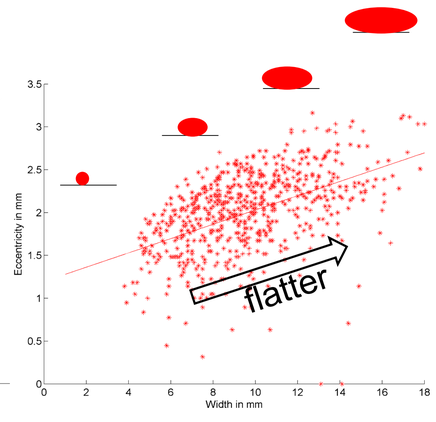
To monitor disease progression and response to therapy in Oncology tumour studies in-vivo.



Tumour growth is easily measured using tumour callipers to obtain length and width measurement. Callipers assume tumours are spheroids with volume of ½ length x width².

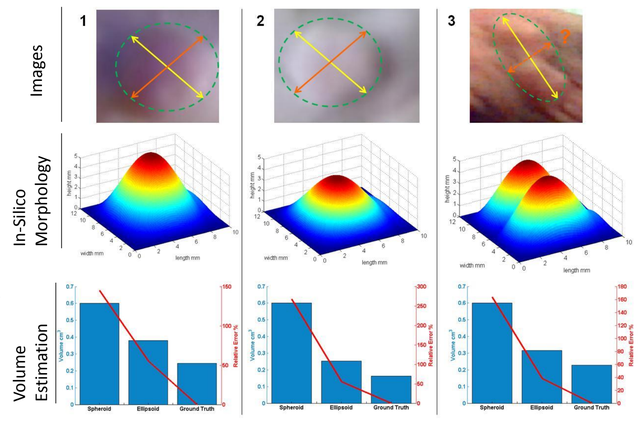
Results show that height is always smaller than width, therefore the spheroid shape is almost always overestimating the volume.



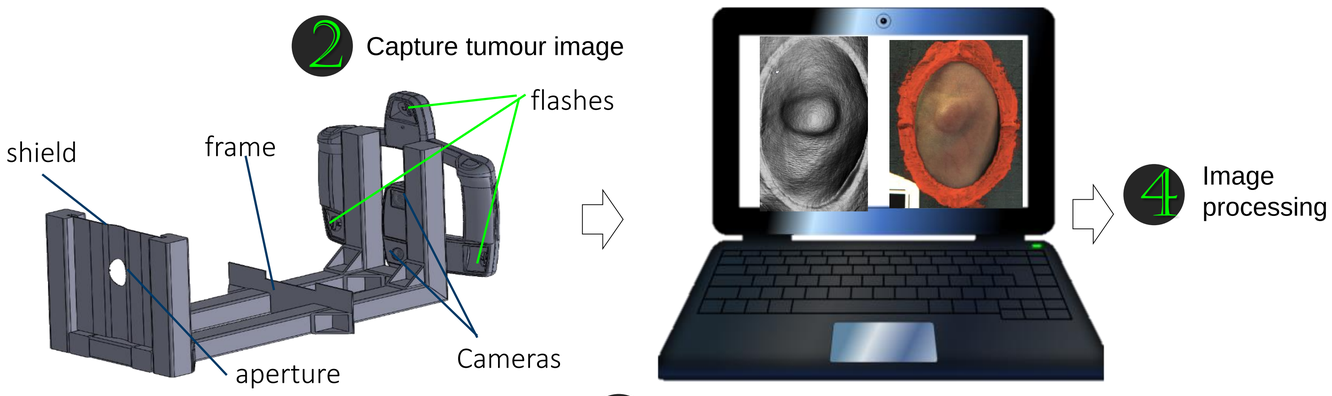


Tumours become more eccentric when growing (error is not homogeneously distributed)

Simulations show that tumours are not spheroids. Flatter tumours diverse especially from the canonical spheroid.

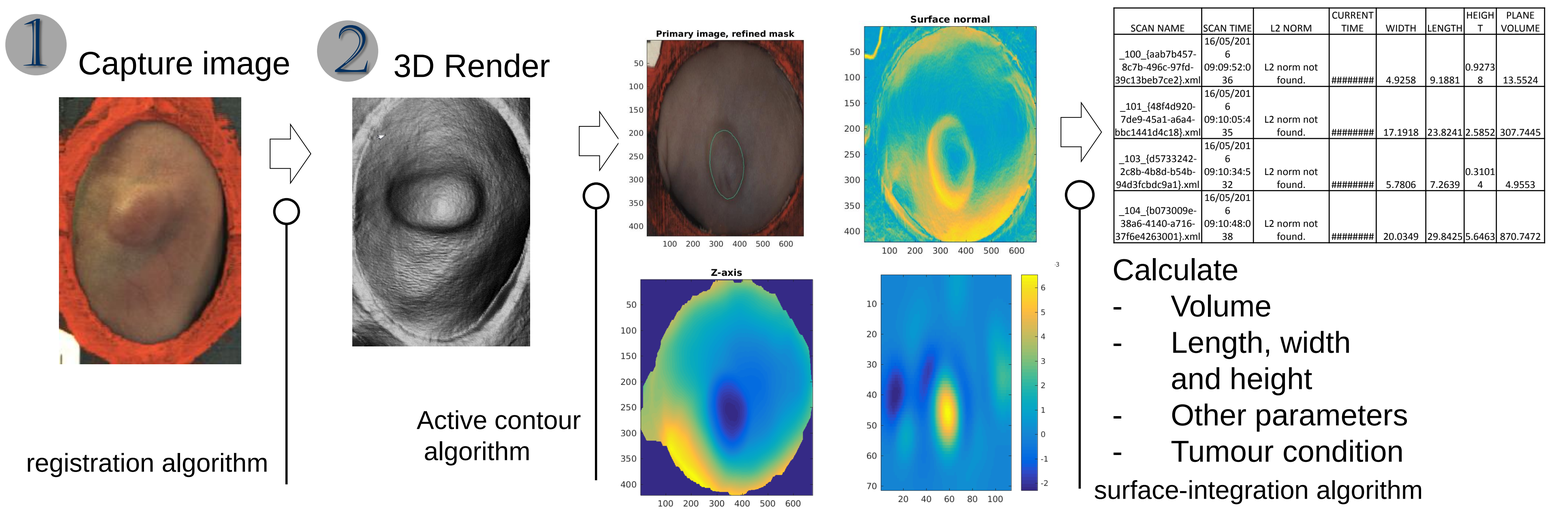


3D scanner – how it works



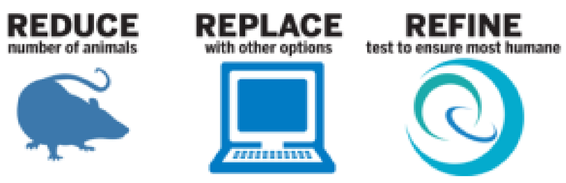
Flashes	three light pulses are flashed on the tumour area
Lenses	two visual lenses tilted
Shield	removable, 3D printed, ergonomically shaped, cleanable, water and solvent resistant
Frame	light, compact, mobile, cleanable, resistant

Image processing method



SCAN NAME	SCAN TIME	L2 NORM	CURRENT TIME	WIDTH	LENGTH	HEIGHT	PLANE VOLUME
_100_{aab7b457-8c7b-496c-97fd-39c13beb7ce2}.xml	16/05/2016 09:09:52.036	L2 norm not found.	########	4.9258	9.1881	0.9273	13.5524
_101_{48f4d920-7de9-45a1-a6a4-bbc1441d4c18}.xml	16/05/2016 09:10:05.435	L2 norm not found.	########	17.1918	23.8241	2.5852	307.7445
_103_{d5733242-2c8b-4b8d-b54b-94d3fcbdc9a1}.xml	16/05/2016 09:10:34.532	L2 norm not found.	########	5.7806	7.2639	0.31014	4.9553
_104_{b073009e-38a6-4140-a716-37f6e4263001}.xml	16/05/2016 09:10:48.038	L2 norm not found.	########	20.0349	29.8425	5.6463	870.7472

Animal welfare & 3Rs benefit across Oncology In-vivo Research



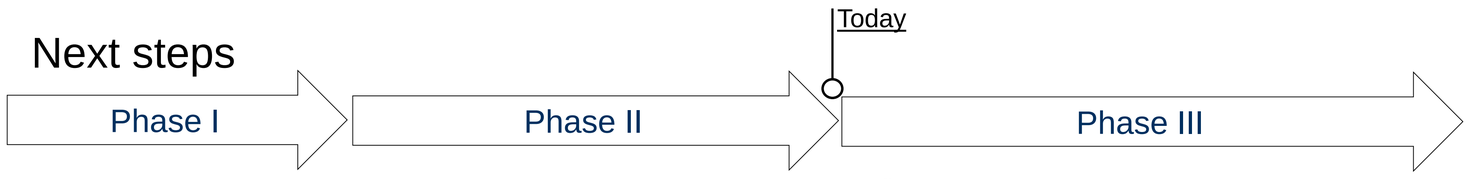
Reduction

+ precision	less animals needed for statistical significance
+ accuracy	less animals needed for scientific endpoint

Refinement

+ faster	reduction of animal handling
+ tracking tumour volume condition	efficient and objective measures for animal welfare
+ morphology independence	irregular tumour models will not compromise the studies
+ independence of operator	more flexible shifts and less qualified staff

Next steps



Proof of concept:
- 600 tumours,
- manual segmentation,
- hardware calibration,
- prototype design

Development:
- ~2k-10k tumours
- multiple strains, sizes, cell lines,
- automatic segmentation (simple morphology),
- software calibration,
- prototype improvement,
- capture of tumour condition

Refinement:
- >10,000 tumours,
- software calibration,
- automatic segmentation (complex morphology),
- connection to database,
- evaluation of tumour condition
- prototype finalisation
- Identification of problems
- software improvement

Reference: Delgado San Martin JA, Worthington P and Yates JWT. "Non-invasive 3D time-of-flight imaging technique for tumour volume assessment in subcutaneous models." *Laboratory animals* (2014): 0023677214562653.

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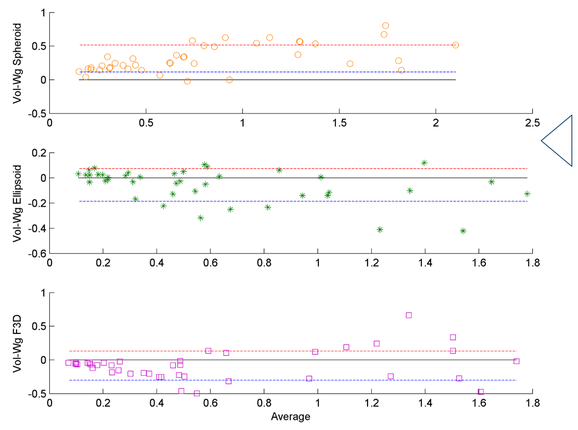
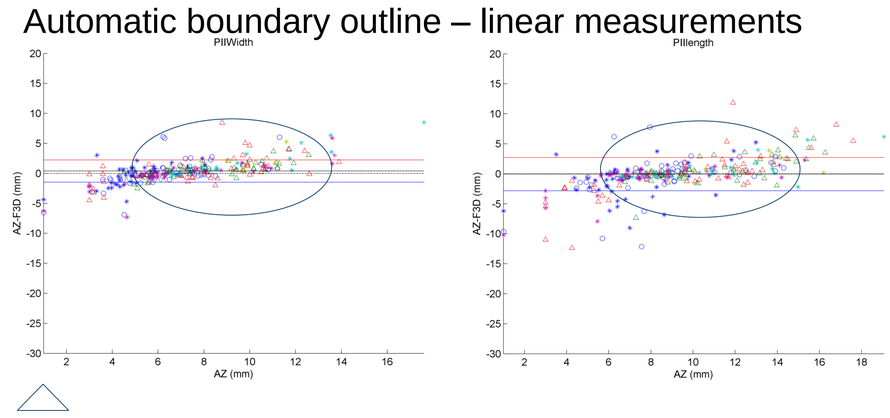
Results: Linear measurements

Manual boundary outline – linear measurements



When tumours are manually outlined on the images width, length and height are very similar to the ones reported with callipers, demonstrating that the camera is reliable at estimating linear measurements.

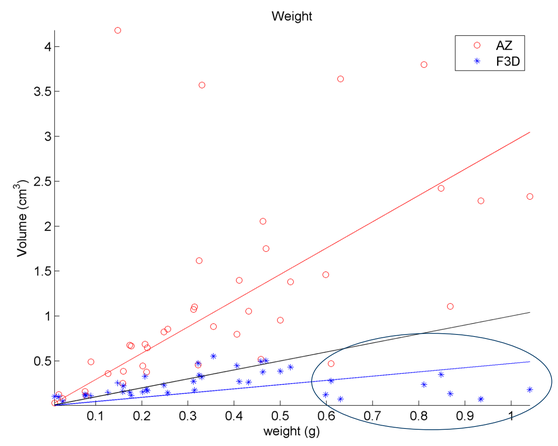
Automatic boundary outline – linear measurements



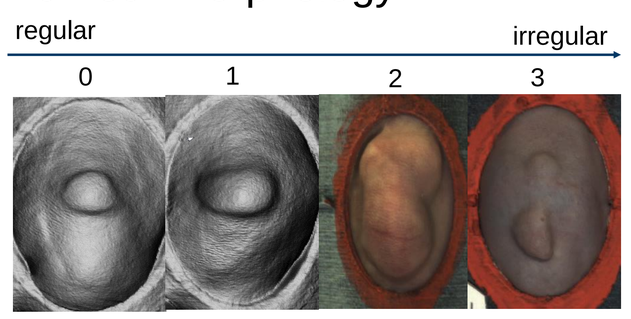
80% of the automatically-recognised tumour boundaries are found within ±2mm. This is currently under development and we will achieve almost perfect accuracy.

Volume estimation

Classical calliper measurements (spheroid) overestimate volumes when compared to its weight. However, Fuel3D scanner have greater accuracy and slight underestimation. Most of the bias is associated to larger tumours.

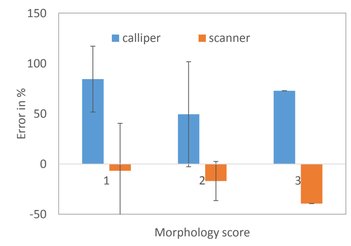


Tumour morphology



More irregular tumours are more difficult to detect by the scanner. At this stage we can only measure morphologies 0-1.

Irregular tumours are poorly measured by callipers, whereas the scanner is morphology-independent demonstrating lower errors.



Symptoms: Potential NC3R's funding

Symptoms such as redness, pallor, or ulceration can be recalled and fed back to a machine learning algorithm to associate different tumour conditions and their outcomes. This is a major refinement in the animal welfare since suffering can be anticipated being able to act about it promptly.