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Noise estimation in PET images

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Aim

Rigshosptialet has recently changed their scanning paradigm to reduce the noise in PET images. This has the purpose of helping the doctors describing the images, as well as reduce the dosage given to the patient. The goal is to analyze if the change of paradigm has reduced the noise, with use of Generalized Linear Models.

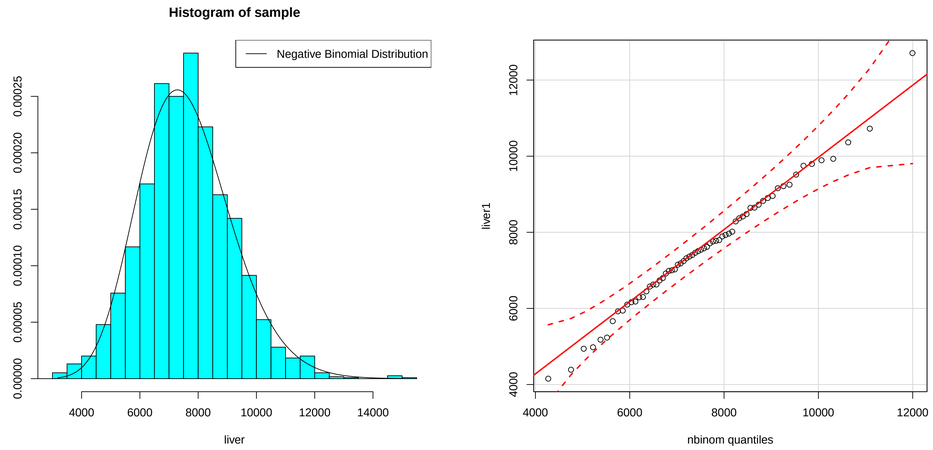
Background for this project

In the old paradigm, the scan duration was determined by the medical laboratory scientists. But in the new paradigm the scan length is determined by the BMI:

BMI	Scanning time [min]
BMI<20	2.5
20<BMI<25	3
25<BMI<30	3.5
30<BMI<40	4
BMI>40	5

Also, in the old paradigm all patients were given 400MBq ^{18}F-FDG, where the new paradigm makes use of weight distributed doses. All patients are now given 4MBq per kg of bodyweight.
In this project, the analysis is made in the liver, as this is assumed to be homogeneous. From analysis of the images, it is seen that the data are not homogeneous. This is known to be noise, where the measurements are thought to be distributed by a negative binomial distribution. This is due to the radioactive decay of the tracer, which is known to be Poisson distributed. In figure 1 and 2 is the distribution for a single patient visualized.
A total of 40 patients were analysed in this project, using both paradigms. To estimate the noise in the liver, a sample of 128 points were taken from each scan for all persons. From these the mean and the variance is estimated.

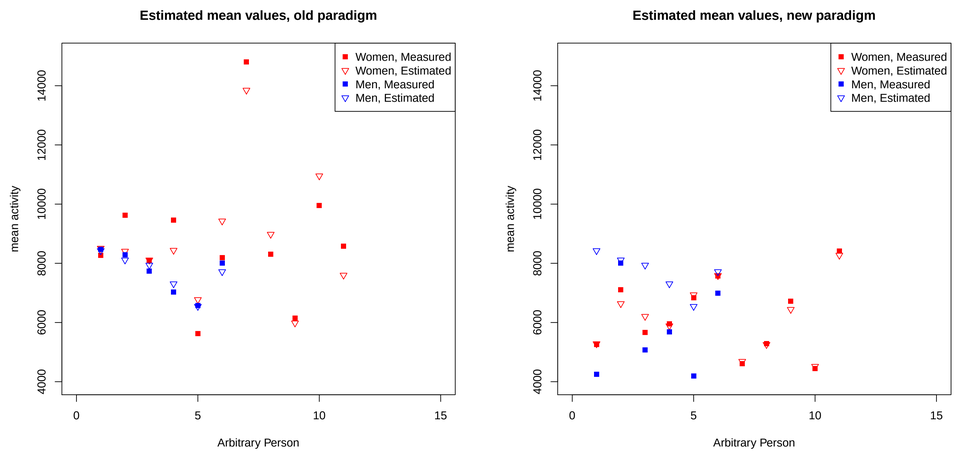
Analysing the distribution it can be found that the data is following a negative binomial distribution:



(a) Data distribution (b) QQ-plot of the data distribution

Figure: Distribution of the data measured in the liver.

From this, a Generalized Linear Model is set up to analyse the mean of the data. It is found that the status (New paradigm/Old paradigm), weight, age, sex, activity, scantime, the scanner and interactions of some of them are significant terms. Analysing the means with respect to measured data the following plots are shown:

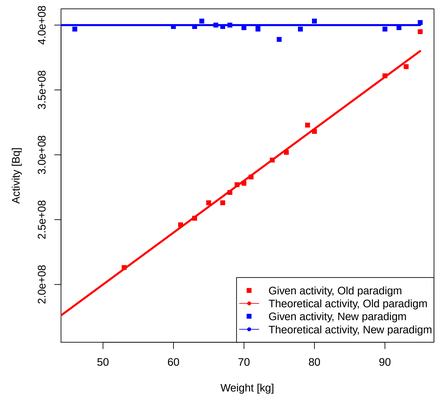


(a) Variance in old paradigm (b) Variance in the new paradigm

Figure: The estimated mean activity compared to the measured mean activity. Divided into old and new paradigm.

Analysing the results

It can be seen that the change of paradigm has reduced the mean activity within the liver. Still, it is visible that some of the data has fairly large residuals, which cannot be explained by the used model. It is assumed that this model is good enough to be used in further analysis. It is shown below how the distributed activities corresponds to the theoretical activities.



Conclusion

From this analysis it is possible to estimate the mean, using parameters measured from the scan. The remaining variance is thought to be other physiological parameters not analysed in this project. This analysis is going to be used in the estimate of the noise in the images.

Further work

As this is a on-going project is the estimation of the noise still to be generated. Before this can be done, an estimation of the variance for the negative binomial distribution needs to be found. This is still under development, but it is expected a model will be found.