# Automated Versus Manual Scan Positioning: a Quantitative Analysis

R. Springorum[1], F. Hoogenraad[1], R. Bergmans[1], S. Young[2], D. Bystrov[2], C. Bos[1]

[1]Philips Medical Systems, Best, Netherlands, [2]Philips Research, Hamburg, Germany

## Introduction

Since the beginning of patient MRI the planning or positioning of slices has been performed manually. The operator uses surveys to define the orientation of the various scans. Manual scan positioning is time consuming and may lead to inconsistent results between operators for various reasons: operator preferences, variations in the initial survey as a result of non-symmetric patient placement, and the limitation imposed by using a limited number of orthogonal slices and landmarks. Automated scan positioning has the potential to improve the consistency with which scans are positioned as it can rely on information covering the whole anatomy [1,2].
In this study we will compare accuracy and consistency for planning brain scans of an automated scan prescription algorithm [3] to that of planning according to current practice by experienced technologists.

## Methods

Twelve healthy subjects were scanned on a 1.5-T clinical MR system (Achieva, Philips Medical Systems, Best, The Netherlands). The subjects were positioned according to normal clinical practice, providing a comfortable, fixed, and slightly variable position. For every subject a standard survey was acquired, consisting of 3 slices in every orthogonal plane: field-of-view 250, matrix 256, acquisition time 17.4 s. In addition, a 50-second 3D survey covering the whole head was acquired; this data was used by the automated scan planning system [3] to delineate major landmarks of the brain. The system, after training by the user, exploits these results to reproduce scan geometries in subsequent subjects.
Datasets of six subjects, (N=6), were used to train the automated planning routine. An experienced technologist prescribed axial slices parallel to the corpus callosum, correcting for AP and FH rotation of the head, and verifying that the whole brain was covered.
The six remaining datasets were used for comparing manual and automated planning: the automated planning routine was run on the 3D surveys to plan the axial geometry. Stack off-centers and angulations of these geometries were recorded. Likewise, six experienced operators, (M=6), were instructed to plan the same axial geometry on the standard survey. The standard survey was intentionally used since this is the routine clinical practice for technologists. Each of the operators was blinded to the plan results of the other operators to prevent bias.
The mean of the manual planning results (angles and off-centers) served as the gold standard. Accuracy and consistency of the automated planning routine, and of the operators were calculated as the mean and standard deviation (SD) of the difference, δ, with respect to this reference. The performance of the automatic planning routine in individual subjects was characterized as the root-mean-square (RMS) difference with respect to this reference, over all subjects. This figure was then compared to the pooled SD of all operators over all subjects, estimated by Eq. 1, which gives a measure of the planning variation encountered in clinical practice.

$$s^2 = \sum_{n=1}^{N}\sum_{m=1}^{M}\delta_{nm}^2 \Big/ N(M-1) \qquad \text{(Eq. 1)}$$

## Results

The automatic planning routine has a RMS deviation under 1.5 deg. on all angulations, Table 1. Specifically, on the RL angulations (alignment with corpus callosum) automatic planning remained within one SD of the manual planning results for all individuals, Figure 1. RMS deviation for RL angulation is only 1.3 deg., whereas the total variation over all operators is clearly larger at 2.2 deg. Finally, results show that the automatic planning does not have a significant bias on any of the geometry parameters, Table 1.

| Parameter | Automatic planning δ (SD) | Overall SD manual | RMS deviation automatic | Ratio |
|---|---|---|---|---|
| Ang. AP (deg) | 0.56 (0.90) | 0.70 | 0.99 | 1.41 |
| Ang. RL (deg) | 0.46 (1.27) | 2.24 | 1.25 | 0.56 |
| Ang. FH (deg) | -0.49 (1.45) | 0.69 | 1.41 | 2.05 |
| Offc. AP (mm) | -1.21 (2.56) | 3.69 | 2.63 | 0.71 |
| Offc. RL (mm) | 0.04 (0.69) | 0.72 | 0.64 | 0.87 |
| Offc. FH (mm) | 1.57 (2.29) | 2.15 | 2.61 | 1.21 |

*Table 1: Analysis results. Ratio gives RMS deviation of automatic planning in proportion to overall SD of manual planning.*

## Discussion and Conclusion

This study shows that there is no systematic difference between automated positioning and manual positioning. All automated positioning results fall well within the variations seen in the group of manually positioning using patient aligned images. Interestingly, data showed that FH and AP angulations and RL off-centers were very accurately planned by all operators, suggesting that the symmetry of the brain in these cases helps to improve planning. The RL angulation, which lacks this symmetry shows greater variation. Here, automated planning provided an important reduction of variability in alignment with the corpus callosum, when compared to a group of technologist planning manually. In conclusion, at sites operated by several technologists, automatic planning can significantly improve the consistency of scan prescription.

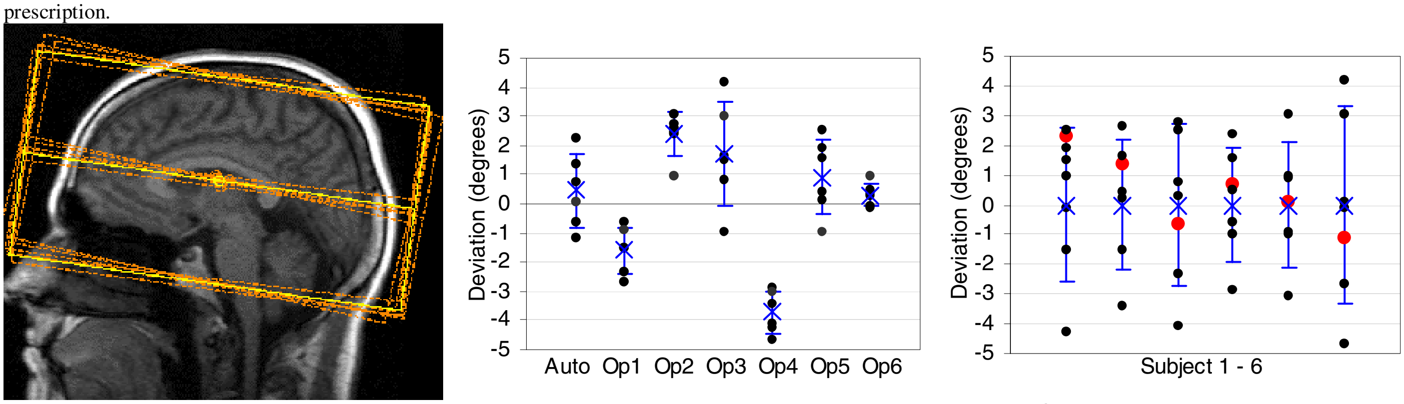


*Figure 1: (left) Planning results on one subject: operators in orange, automatic planning in yellow. (middle) Deviations δ on the RL angulation per operator. Crosses indicate mean, error bars indicate SD, dots are individual data points. (right) Deviations δ on the RL angulation per subject. Here, by definition, mean in all cases is zero. Planning by the automated planning system (red circles) is seen to be within the SD of all operators for every subject.*

## References

[1] Itti L et al., Magn Reson Med 2001; 45: 486. [2] Lelieveldt BP et al., Radiology 2001; 221:537. [3] Young S et al., SPIE Medical Imaging 2006; Accepted.