Scalability and channel independency of the digital broadband dStream architecture

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Introduction

Since the introduction of parallel imaging techniques [1,0], the numbers of elements in phased array coils have been continuously increasing to achieve high SNR and short scan time. In order to acquire the signal of those elements, the typical MR systems have had to support an increasing number of receive channels. Typical MRI systems are equipped with 8 receive channels as standard, with options for 16 and 32 channels. This trend towards higher number of channels has resulted in an increased complexity of the MRI system [0] with increased initial costs; subsequent upgrades to increase the number of channels is also costly because a substantial expansion of the RF chain is required. Moreover, the connection to the system of a coil with more elements than the number of receive channels forced developers to build complex logic switches in the coil and/or to multiplex and compress the signal [4,5]. This work describes a scalable digital broadband receive system architecture which no longer limits the number of receive channels that can be connected and provides a consistent signal fidelity independent of the number of channels.

Methods and Materials

In the *dStream* architecture of the *Ingenia* system (Philips Healthcare, Best, The Netherlands), the MR signal of each coil element is processed and digitized directly inside the coil, therefore there is now no distinction whatsoever between the number of coil elements/channels and the number of receive channels of the MR system. High channel count coils are realized in this architecture by simply adding more elements/coils and acquiring and digitizing the signal from each element in a fully independent fashion. This approach is in contrast to other popular approaches that utilize local analogue combination, compression and multiplexing of the signals in order to match the number of elements with the number of channels [5]. This analogue signal manipulation, together with long galvanic cables, can lead to signal degradation and channel crosstalk resulting in unpredictable SNR losses and artefacts, particularly as more channels are added. The *dStream* architecture avoids this. A further advantageous feature of the *dStream* architecture is that the multiple, directly digitized, MR signals are transmitted from each coil to the reconstruction engine via a single optical fiber (independent of the number of elements). Since all coil control signals, e.g., tune, detune, diagnostics, etc., are also digitally communicated via the same fiber, adding and controlling additional elements, or even complete multi-element coils, can be done with no impact on the installed receive chain infrastructure and with a minimum number of optical connectors.

The easy scalability of this architecture was demonstrated by connecting and imaging with various coil sets with varyingly large numbers of elements. In one test, a total of 48 elements covering the head and whole spine were attached. In the second test a total of 74 elements were connected covering the head, neck and thoracic chest, including 2 specialist sections of 4 elements each on the cervical carotids. Apart from the coils themselves (in the examination room), no other modifications were made to the MR system. Because MR signal digitization occurs inside the coil, the same system can scan with an increased number of elements without any modification of the receive chain. There was no need to compress or multiplex the signals in order to acquire data from all attached elements. 3 volunteers were scanned; examination with contrast agent was not permitted.

Results

Using a 48-element array of coils, sagittal images of the whole neuro-axis were acquired (at 3.0T) with a resolution of 0.8x1.0mm and slice thickness 4mm, with a total field of view of 84x30cm. T2w and T1w images were acquired in a total scan time of 7m32s and 10m21s respectively (fig 1). In a second examination using the same coil arrangement, 30 coronal T2w images of the whole body were acquired in a total scan time of 30s (fig 2). With a 74-element array of coils, in-flow MR angio images were acquired from the arch of aorta to the vertex of the skull in a total scan time of 9m20s (fig 3). T1w, PDw and T2w images were acquired perpendicular to the internal carotid artery just distal to the carotid bifurcation with high in-plane resolution of 0.5x0.7mm and 3mm slice thickness (fig 4).

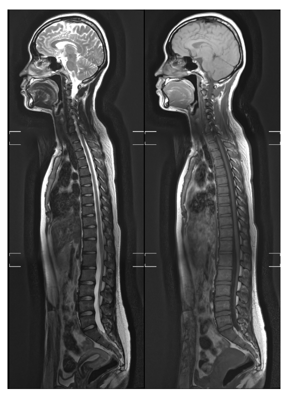

Fig 1: Whole neuro-axis

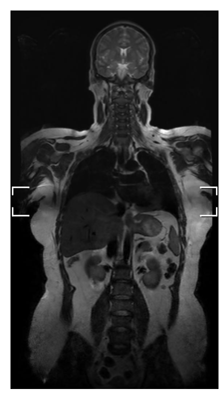

Fig 2: Whole body

Fig 3: MRA

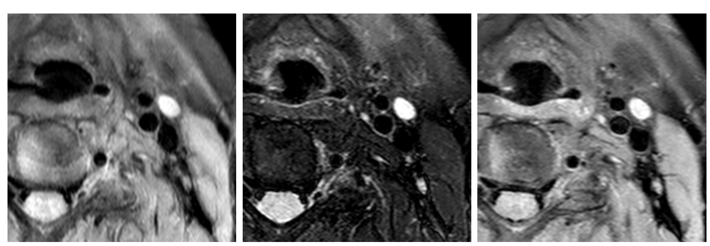

Fig 4: (L to R) PDw, T2w and T1w carotid wall

Conclusions

The full scalability of the *dStream* architecture in the *Ingenia* system allows to connect various coil sets with increasingly large numbers of elements. For this initial study, standard imaging protocols were used in order to maximize SNR. Increasing the 'channel count' of the system was achieved simply by placing additional coils on the patient support, without modifying anything on the installed receive chain of the system.

References

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