Intermediate Report

FETUS

Fetus and pregnant woman Exposure to Telecom new wireless Usages and Systems

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This report was compiled for the ANR-JST Joint workshop which was held in Kobe, Japan in March 2012.
This report summarised FETUS group research activity of first half research period.
本報告書は、2012年3月に神戸で開催された領域内中間ワークショップのために編纂されました。研究グループの研究期間前半の活動内容をまとめたものです。

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A IDENTIFICATION

Project acronym	FETUS
Project title	*Fetus and pregnant woman Exposure to Telecom new wireless Usages and Systems*
Project coordinator (French side) (company/organization)	Orange Labs
Project coordinator (Japanese side) (company/organization)	National Institute of Information and Communications Technology (NICT)
Project start date Project end date	2010/05/31 2013/05/31
Competitiveness cluster labels and contacts (French side) (cluster, name and e-mail of contact)	
Project website if applicable	http://whist.institut-telecom.fr/fetus/

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E-mail	
Date of writing	
Period covered by activity report	2010/05/31 – 2011/12/31

B DELIVERABLES AND MILESTONES

No.	Designation	Nature*	Date of supply			Partners (underline the responsible partner)
			Initially planned	Re-scheduled	Deliv-ered	
1			12/11			
			M3			

C PROGRESS REPORT

C.1 INITIAL OBJECTIVES OF THE PROJECT

Over the past 30 years the wireless communication systems such as mobile phones have been increasingly used. In spite of existing protection limits there is worldwide a public concern about possible health risk linked to the electromagnetic field exposure. Many studies have been conducted so far but more studies have to be conducted, more particularly studies focusing on children, fetuses and pregnant women exposure. The estimation of the RF fetus exposure induced by new wireless communication is however highly complex since new technologies can be used in versatile ways and since the exposure depends on many parameters (usage, frequency, posture, age of fetus). Progress in computation technique can help to manage the problem but usual dosimetric approaches are not well adapted to handle such problems.
The exposure assessment of fetuses is facing 3 major challenges: The first challenge is the limited number of anatomically correct models (MRI based or Ultrasonic based) of mother and fetus that can be considered as reliable for the exposure assessment. The second challenge is the lack of tools that allow deforming the fetus and mother models in a correct anatomical way. And the third challenge is the management of the complexity of this problem to assess the statistical distribution of the exposure and by this way the maximum exposure. The objectives of the FETUS project are:

- Develop new fetus models and new pregnant woman models
- Develop new tools to deform models in order to create new postures taking into account the anatomical deformations of the fetus and maternal tissues encountered with new usages and new wireless technologies.
- Assess the exposure in different configurations and analyze the influence of parameters (e.g. posture, frequency).

- Determine the uncertainty relative to variable configurations of the fetus exposure.

C.2 WORK PERFORMED AND RESULTS ACHIEVED IN THE FIRST HALF PERIOD

Task 1: Configurations to Cover

- Literature survey and technical-trend investigation concerning existing pregnant female models and concerning numerical dosimetry on pregnant female models
- Analysis performed in France on data concerning the positioning of the fetus at different stages during the pregnancy

Task 2: Mother and Fetus imaging data gathering and segmentation

- MRI sequence and parameters for developing high-resolution fetal models were investigated in Japan
- Some fetal MRI data of last trimester of pregnancy were acquired in Japan and fetal models at 32 and 33 weeks of gestation segmented into over 20 different tissue types were developed.
- In France, the segmentation method relies on the estimation of the statistical distribution of image intensities in each tissue, and its integration in deformable models based on a level set formulation. In MRI, the segmentation is driven by a preliminary detection of landmarks (eyes, bones, etc.), the registration of a fetus model, and a graph cut segmentation approach.

Task 3: Model and organ Deformation, Insertion of Fetus in mother

- Software developed by Telecom ParisTech to insert fetus models inside a synthetic semi-homogeneous non-pregnant woman model (named Victoria, provided by Daz Studio): The synthetic non-pregnant woman model is composed of skin layer, subcutaneous fat layer, muscles, pelvis and an homogeneous tissue representing all other tissues. The subcutaneous fat layer thickness is a variable parameter, based on measurements performed on pregnant women in France and in Japan. The amniotic fluid quantity is also a variable parameter. The Uterus+Fetus unit can be inserted in any position inside Victoria.
- Software developed by Telecom ParisTech to position pregnant woman models.
- FEMONUM fetus models partly inserted inside Victoria.

Task 4: Source, Posture and configuration modelling

- In Japan, SAR induced in the fetus by a simplified antenna model (planar inverted F antenna with metallic case) and a French cellular model were calculated. Moreover, modelling of four Japanese mobile radio terminals have been prepared by taking X-ray and their disjointing.
- 15 different sources modelled: phones representative of commercial phones in Europe (bar phones, slide phones, flip phones, PDAs, smartphones), 3G USB key, laptop, tablet.

Task 5: Exposure calculation

- Dominant Factors affecting local and core temperature elevations were identified.
- Validation of synthetic semi-homogeneous pregnant woman model – Evaluation of dielectric properties to use for the homogeneous tissue.
- Exposure calculation with a pregnant woman model segmented from MRI images by Telecom ParisTech and with a pregnant woman model developed by NICT from the non-pregnant Japanese woman model HANAKO

- Intercomparison between NITECH, NICT and Orange Labs of the mother and the fetus exposure using the Japanese pregnant woman model (results to be published)

Task 6: Exposure analysis and uncertainty estimation
Exposure of fetus is depending on many parameters that can be considered as random variables and we are looking for the distribution of the fetus exposure (quantified by the whole body averaged SAR). As computation cost is still high, we are working on a sequential design of computer experiments for the estimation of a given quintile (for example the 95^{th} quintile) of the fetus exposure. The method is based on a Gaussian process approximation. From a set of initial observation points, next points are iteratively chosen to improve the estimation of the quintile. By now, the method has been implemented and validated for 1- and 2-dimensions.

C.3 WORK FORECAST IN THE SECOND HALF PERIOD

Task 1: Configurations to Cover

- Follow-up survey concerning pregnant female models and numerical dosimetry.

Task 2: Mother and Fetus imaging data gathering and segmentation

- Some Japanese fetal models will be developed from fetal MRI data of second trimester of pregnancy.
- Anatomical and physical assessments of fetal models developed in Japan and France.
- On the french side, on-going work in the FETUS project focuses on the enrichment of 1st trimester fetuses models based on a brain segmentation method for US data, and enrichment of the pregnant women model using CT-scan data (kidney addition). A collaboration with Japanese teams in order to build fetuses models during the 2nd trimester of pregnancy is expected.

Task 3: Model and organ Deformation, Insertion of Fetus in mother
Physically-based deformations will also be continued. Fat modelling will be refined based on clinical data provided by collaborating hospitals, and its deformation will take gravity forces into account.

Task 4: Source, Posture and configuration modelling
Four Japanese mobile radio terminal models will be constructed. Thereafter, SAR distributions will be calculated using Japanese and French models by both Japan and France groups. The effects of the pregnant female and fetus poses for estimating the SARs will be also evaluated.

Task 5: Exposure calculation

- Variability of SAR will be investigated for different fetus models and exposure scenarios: different subcutaneous fat layer thicknesses, different amniotic fluid quantities, different positions of the fetus, different pregnancy stages, far-field and near-field exposure to different sources.
- Resultant temperature elevation in the models of fetus and mother will be investigated.

Task 6: Exposure analysis and uncertainty estimation

- Next step is to implement and validate the sequential design of computer experiments in higher dimensions and to apply it to the fetus exposure.
- A simplified analytical model based on cylinders and ellipsoids is going to be built to assess faster the exposure of the fetus and to use the sequential design of computer

experiments.

- Based on results from computer experiments a surrogate model will be built.
- This surrogate model makes possible to compute a larger number of SAR simulation. These simulations are then used to assess the level of SAR seen by the fetus with a given probability (e.g. 95%).

C.4 DIFFICULTIES ENCOUNTERED AND SOLUTIONS

Technical meeting scheduled in Tokyo, Japan on April 2011 has been cancelled, due to Earthquake, Tsunami and nuclear accidents that happened in Japan on March 2011, and it was difficult for Japanese partners to carry out the Fetus Project in a planned manner during a half-year from March 2011.

Although several models are already available and progressively refined, we are still missing data during the 2nd trimester of pregnancy. This is due to the fact that 3D US cannot cover the whole uterus at this stage, and that MRI acquisitions are seldom performed.

C.5 SIGNIFICANT EVENTS AND RESULTS

C.6 WORK SPECIFIC TO THE COMPANIES (WHERE APPLICABLE)

Company xxx.

Company	Orange Labs
Author (name + e-mail address)	Joe Wiart joe

Orange Labs has been mainly involved in the Fetus project in the exposure calculation and the exposure analysis (tasks 5 and 6). New technologies that are using EMF induce questions and fears, in particular focused on organism in development such as children and fetus. Even if below the protection limits there is no evidence of sanitary effect, the questions exist and the uncertainty relative to the EMF risk assessment can depress general public to use innovative wireless systems. A large part of the digital economy will go through wireless technology but such intensive use of EMF has also strengthening the public fears. At the centre of present questions are the permanent exposure and the children exposure including fetus and pregnant woman. Recently WHO has recommended the study on the EMF dosimetry relating with fetuses as high-priority research topics. The purpose of the project for our company is to be able to give answers concerning the exposure to EMFs of pregnant women and fetuses, to quantify the real exposure. It is very important to have studies that have assessed the exposure in order to inform the public on the real exposure induced by wireless systems even if well below the protection limits. The project FETUS will help to provide information and strengthen the acceptance of new wireless technologies.

Company	Phimeca
Author (name + e-mail address)	Thierry YALAMAS

Phimeca is mainly involved in exposure analysis and uncertainty estimation (Task 6). To be really achieved, this task needs to have numerical model available (Tasks 3, 4 & 5). Nevertheless, Phimeca has for now focused its work on methodological development in order to be ready when models will be available. These methodological developments deal with the capacity to take into account correlated variables in sensitivity analysis and the ability to build robust surrogate models with a few numbers of initial simulations.

These methodologies are very innovative and fetus project contribute to enhance Phimeca's knowledge. All these methods are (or will be) used by Phimeca in the study performed for industrial clients and some of them will be implemented in commercial software (PhimecaSoft).

C.7 Consortium meetings (collaborative projects)

Date	Place	Partners present	Subject of the meeting
2010/05/17	Tokyo Yaesu Hall, Japan	NICT, Chiba University, NITECH	Kick-off meeting of Japanese partners
2010/05/31	Telecom ParisTech, France	Orange Labs, Telecom ParisTech, Telecom Bretagne, Phimeca, NICT, Chiba University, NITECH	Kick-off meeting
2010/10/18	NICT, Japan	NICT, Chiba University, NITECH, KCMC	Pre-meeting of Japanese partners to prepare the Realmeet meeting
2010/10/27	Realmeet (Orange Las, Issy les Moulineaux and Orange Labs, Tokyo)	Orange Labs, Telecom ParisTech, Phimeca, NICT, Chiba University	Technical meeting
2010/12/01	Orange Labs, France	Orange Labs, Telecom ParisTech, Telecom Bretagne, Phimeca, NICT, Chiba University, NITECH	Technical meeting
2011/04/05	NICT, Japan		Cancelled technical meeting
2011/07/04	Orange Labs, France	Orange Labs, Telecom ParisTech, Telecom Bretagne	French partners technical meeting

C.8 Free comments

Comments from the French/Japanese coordinators (PIs)

Comments from the other cooperate researchers

Question(s) posed to the ANR/JST

D PROJECT VALORIZATION AND IMPACT SINCE BEGINNING

D.1 PUBLICATIONS AND COMMUNICATIONS

<Joint> Multinational Joint Papers, etc

List of the Multinational publications (resulting from jointly conducted work)		
International	Peer-reviewed journals	1. Estimation of Whole-Body Averaged SAR of Grounded Human Models for Plane Wave Exposure at Respective Resonant Frequencies (to be submitted in Physics in Medicine and Biology). 2. 3.
	Books or chapters in books	1.
	Communications (conferences)	1. J. Wiart, S. Watanabe, I. Bloch et al. "**Fetus RF exposure analysis. Preliminary results based on three realistic 3D digital models"**, URSI 2011 2. J. Wiart, S. Watanabe, I. Bloch et al. **"Exposure of fetuses to RF - Preliminary results assessed with different realistic 3D numerical models**" BEMS 33rd Annual Meeting, Dalhousie University, Halifax, Nova Scotia, Canada June 12 - 17, 2011 3. MICCAI 2012 in preparation
France	Peer-reviewed journals	1.
	Books or chapters in books	1.
	Communications (conferences)	1.
Japanese	Peer-reviewed journals	
	Books or chapters in books	
	Communications (conferences)	
Outreach initiatives	Popularization articles	1.
	Popularization conferences	1.
	Others	

<French side> Single partner Papers, etc

List of single-partner publications (involving a single partner)		
International	Peer-reviewed journals	1. J. Wiart et al., "Numerical dosimetry dedicated to children", Progress in Biophysics and Molecular Biology 107 (2011) pp. 421-427 2. Lazar Bibin, Jeremy Anquez, Juan Pablo de la Plata Alcalde, Tamy Boubekeur, Elsa D. Angelini et Isabelle Bloch. Whole Body Pregnant Woman Modeling By Digital Geometry Processing With Detailed Utero-Fetal Unit Based On Medical Images. IEEE Transactions on Biomedical Engineering, vol. 57, n° 10, pp. 2346-2358, 2010
	Books or chapters in books	1. 2.
	Communications (conferences)	1. Bert Buchholz, Tamy Boubekeur, Sylvain Paris, Noura Faraj, and Elmar Eisemann. **Parameterizing animated lines for stylized rendering**. *In ACM SIGGRAPH 2011* – Talk Program , 2011. 2. Bert Buchholz, Noura Faraj, Sylvain Paris, Elmar Eisemann, and Tamy Boubekeur. **Spatio-temporal analysis for parameterizing animated lines**. *In International Symposium on Non-Photorealistic Animation and Rendering (NPAR)*, 2011. 3. Juan Pablo De La Plata, Jeremie Anquez, Lazar Bibin, Tamy Boubekeur, Elsa Angelini and Isabelle Bloch. **FEMONUM: A Framework for Whole Body Pregnant Woman Modeling from Ante-Natal Imaging Data.** Eurographics 2011 - Honorable Mention of the Dirk Bartz Prize for Visual Computing in Medicine 2011 4. Y. Pinto, A. Ghanmi, A. Hadjem, E. Conil, T.Namur, C.Person and J.Wiart, **"mobile phones simulating models validated by SAR distribution measurements"** –, EuCAP 2011, 11-15 April

		2011, Rome
France	**Peer-reviewed journals**	1. 2.
	Books or chapters in books	1. 2.
	Communications (conferences)	1. Noura Faraj, Jean-Marc Thiery and Tamy Boubekeur. **VoxMorph**. *In Proceedings of Journées de l'Association Française d'Informatique Graphique (AFIG)*, Bidart, France, 12-14 octobre 2011 2. Yenny Pinto, Abdelhamid Hadjem, Emmanuelle Conil, Christian Person, Joe Wiart, **« Analyse de l'exposition d'un FOETUS par un téléphone mobile dans les bandes GSM et UMTS »**, 17èmes JNM2011, Brest, Mai 2011
Outreach initiatives	**Popularization articles**	1. Christian Person, contribution dans l'Article "Ces ondes qui planent au dessus de la tête de nos enfants », Le monde, 11 janvier 2011 2.
	Popularization conferences	1. Christian Person, «Ondes électromagnétiques & Dosimétrie» Matinale de Rennes « Interaction ondes-vivant : aujourd'hui et demain », 9 décembre 2010, Rennes
	Others	1. Christian Person **"Characterisation and use of advanced materials for microwave and millimeterwave applications – Part 1 : Dosimetry and SAR Assesment - Part 2 : Biological Effects of microwave electromagnetic fields"** 29-1er décembre 2010 & 2011, Erasmus Lecture, Universidad Politécnica de Valencia

<Japanese side> Single partner Papers, etc

List of single-partner publications (involving a single partner)		
International	**Peer-reviewed journals**	1. Anatomic dependency of phase shifts in the cerebral venous system of neonates at susceptibility-weighted MRI. J Magn Reson Imaging. 34 (2011) pp.1031-1036. 2. Dominant factors affecting temperature rise in simulations of human thermoregulation during RF exposure, Physics in Medicine and Biology, vol.56, pp.7449-7471, 2011.
	Books or chapters in books	1. 2.
	Communications (conferences)	1. Spatial dependency of phase shift in the cerebral venous system of neonates using susceptibility-weighted magnetic resonance imaging. ECR 2011 2. Impairment of the medullary veins on neonatal subependymal hemorrhage using susceptibility-weighted imaging. ISMRM 2011 3. Effective performance of T1-weighted FLAIR brain imaging with BLADE in children. ESMRMB 2011 4. Effects of Dielectric Properties of Gestational Tissues on the Estimated SARs of Fetuses in Pregnant Females during Electromagnetic Field Exposure. 6th International Workshop on Biological Effects of Electromagnetic Fields, 2010 5. A GPU-Based Calculation Using the Three-Dimensional FDTD Method for Electromagnetic Filed Analysis. 32nd Annual International Conference of the IEEE Engineering in Medicine and Biology Society. 2010 6. Specific Absorption Rates of Fetuses in Seated Pregnant Female Models from 30 MHz to 2 GHz. 33rd Annual Meeting of the Bioelectromagnetics Society. 2011 7. GPU-Based 3D-FDTD Computation for Electromagnetic Field Dosimetry. IEEE Africon 2011.(Outstanding paper award) 8. SAR calculations in fetus exposed to EM waves from half-wave length dipole antenna, The Bioelectromagnetics Society 33rd Annual Meeting, PA-103 9. Conservative estimation of whole-body averaged SAR in grounded human models for plane wave exposure at resonant frequencies, Asia-Pacific Electromagnetic Compatibility, T-We3-2, 2011.
Japanese	**Peer-reviewed journals**	3. 4.
	Books or chapters in books	1. Utilities of MRI for pediatric patient. Shonika. 2011:52;1661-1666 2. MRI. Shusanki Igaku 40 (2010) pp.853-856 3. Current radiological development. Shoni Geka 42 (2010) pp.573-584

	Communications (conferences)	1. Basic assessment for utilities of T1-FLAIR-BLADE. JSMRM 2010 2. Utilities of T1-FLAIR-BLADE for pediatric brain at 1.5T and 3T. JSMRM 2010 3. Hypoxic-ischemic injury on neonates. JCR 2010 4. Utilities of MRI for pediatric neuroscience. JSMN 2010 5. Phase shift in the neonatal venous system using susceptibility-weighted imaging. JSNR 2011 6. Lung-to-liver signal ratio on fetal MRI: comparison between HASTE and true-FISP. JSMRM 2011 7. Kusagiri K, Niwa T, et al. Whole-body fetal MRI using 3D-FISP. JSMRM 2011 8. Current technique of MRI for pediatric patients. JSMRM 2011 9. High-speed three-dimensional FDTD computation for numerical dosimetry of human body using GPU. IEICE Society Conference 2010 10. SAR calculations in fetus due to EM wave from half-wave length dipole antenna using a fetus model of standard body weight, Proceedings of the 2011 IEICE general conference, p.111 11. Comparison of fetal SARs between three different gestation ages, Proceedings of the 2011 IEICE Society conference, p.333 12. Evaluation of the fetal temperature elevation for 13, 18, and 26 gestational weeks, Proceedings of the 2012 IEICE general conference 13. Estimation of Whole-Body Average SAR in Grounded Human Models for RF Far-Field Exposures, IEICE MW2010-53, 2010. 14. Dependence of Whole-Body Averaged SAR on Separation between Human Body and Perfect Conductor for Plane-Wave Exposures, Proc. IEICE General Conf, B-4-15, 2010. 15. Estimation Scheme of Whole-Body Average SARs in Grounded Human Models at Resonance Frequencies, IEICE EST2011-65, 2011.
Outreach initiatives	**Popularization articles**	3. 4.
	Popularization conferences	1. 2.
	Others	1. 2.

D.2 OTHER VALORIZATION FACTORS

List of factors. Indicate the titles, years and comments	
International patents obtained	1. 2.
International patents pending	1. 2.
French National patents obtained	1. 2.
Japanese National patents obtained	3.
French National patents pending	1. 2.
Japanese National patents pending	3.
Operating licences (obtained / transferred)	1. 2.
Company creations or spin-offs	1. 2.
New collaborative projects	1. 2.
Scientific symposiums	1. 2.
Others (specify)	1. Contribution to scientific council Institut Telecom 2.

E Appendices

Details on the work performed at Telecom ParisTech

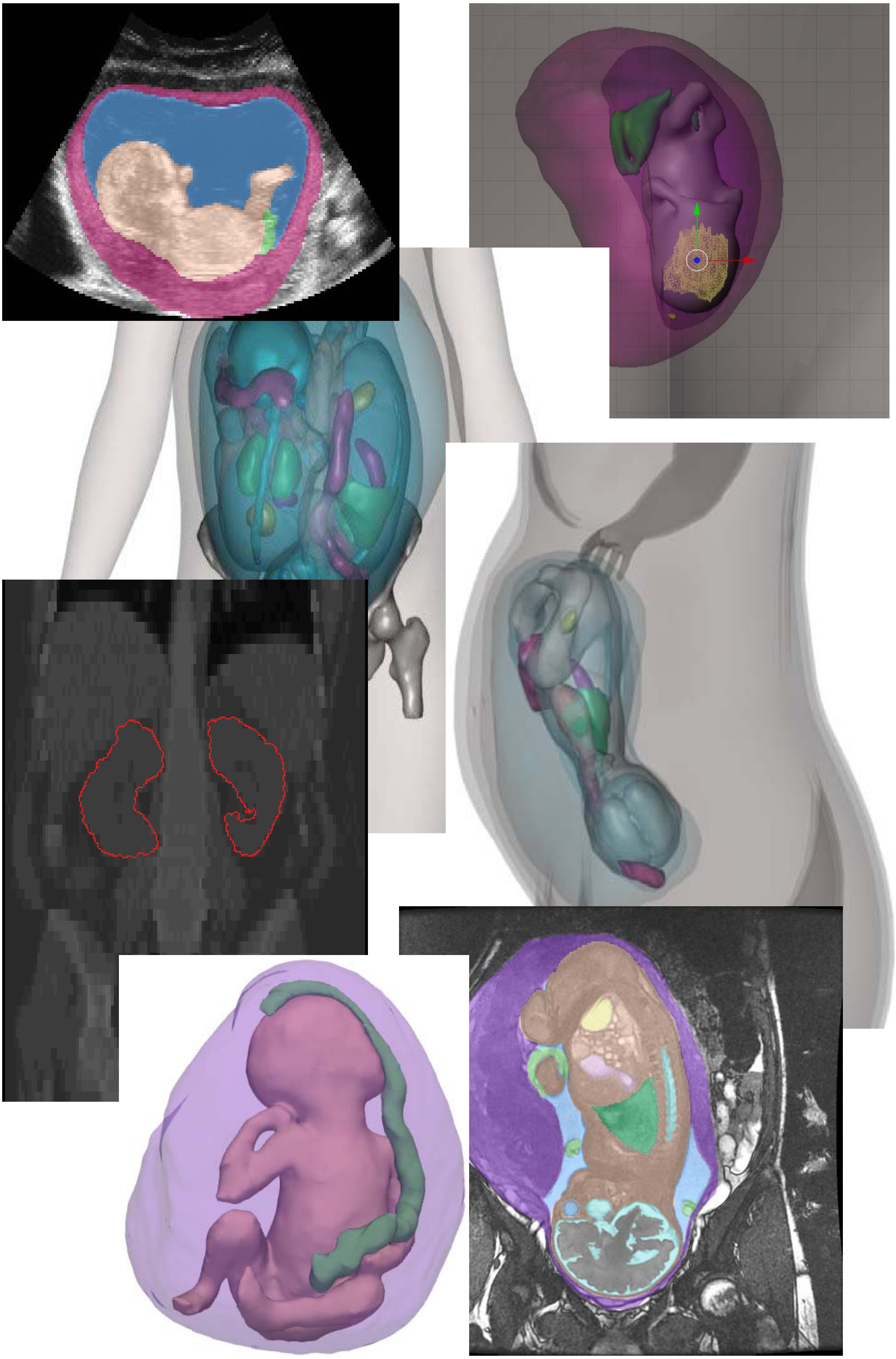
The segmentation method in 3D US method relies on the estimation of the statistical distribution of image intensities in each tissue, and its integration in deformable models based on a level set formulation. In MRI, the segmentation is driven by a preliminary detection of landmarks (eyes, bones, etc.), the registration of a fetus model, and a graph cut segmentation approach. Segmentation results are included in a synthetic woman model (Victoria, provided by Daz Studio, which is deformed according to medical data about pregnancy. Specific attention was put on fat modeling. The 3D models are built using Blender and Sofa, including semi-automatic deformation of the pregnant woman body in order to simulate fetus growth, deformation of the pregnant woman body in order to simulate different corpulences, and take into account physical constraints.

As for the deformation part of the project, we propose VoxMorph, a new interactive freeform deformation tool for high resolution voxel grids. Our system exploits cages for high level deformation control. We tackle the scalability issue by introducing a new 3-scales deformation algorithm composed of a high quality as-rigid-as possible deformation at coarse scale, a quasi-conformal space deformation at mid-scale and a new deformation-adaptive local linear technique at fine scale. The two first scales are applied interactively on a visualization envelope, while the complete full resolution deformation is computed as a post-process after the interactive session, resulting in a high resolution voxel grid containing the deformed model. We experimented our systems on various real world high resolution data sets and report measures demonstrating that our approach offers a good balance between performance and quality.

Figure 1: **A 3-scales deformation pipeline:** the input voxel grid (left) deformation process is controlled by the mean of a coarse cage with non linear as-rigid-as-possible deformation (middle left). When reaching a satisfying shape, the deformation is first transfered to a deformation-adaptive mid-resolution volume mesh using cage coordinates (middle right). The full resolution voxel grid is finally rasterized in its deformed space using a so-defined per-simplex linear deformation (right).

Figure 2: Deformations of a high resolution full body segmented 3D medical image using our system.

Some illustrations on segmentation and 3D models.



Details on the work performed at Telecom Bretagne

The RF exposure assessment is nowadays a fundamental issue for wireless communication systems. Several studies have shown that the Specific Absorption Rate (SAR) depends on factors such as morphology, posture but also on source characteristics and location. To analyse the RF exposure of specific organs such as brain or genital organs, representative sources model are requested. Recent studies focused on RF sources models present specific CAD models based on commercial applications as computers or mobile phones In the project Fetus, Telecom Bretagne have developed several phone models that are representative of current commercial ones (multi-band having antenna in different positions), with the perspective of exchanging this models with the Japane partners of the project as well as the research teams involved in the segmentation image tools. SAR simulations and measurements of several mobile phones and different representative numerical models have been developed and validated in the GSM bands (900MHz and 1800MHz), WIFI (2.45GHz) and UMTS band (2100MHz).

The simplified models are based on commercial phones, slide, bar, smart…) because it is an interesting configuration due to the fact that two different models depending on the use conditions (open phone and close phone) can be represented. Figure 2 shows the implemented models to be used in the FDTD method
Les figures 2 illustrent quelques exemples de différents modèles d'antennes GSM existantes dans de modèles de mobiles commerciales. Nous pouvons regarder les différentes géométries qui peuvent être utilisées, en effet ces antennes sont conçues pour fonctionner à deux bandes.

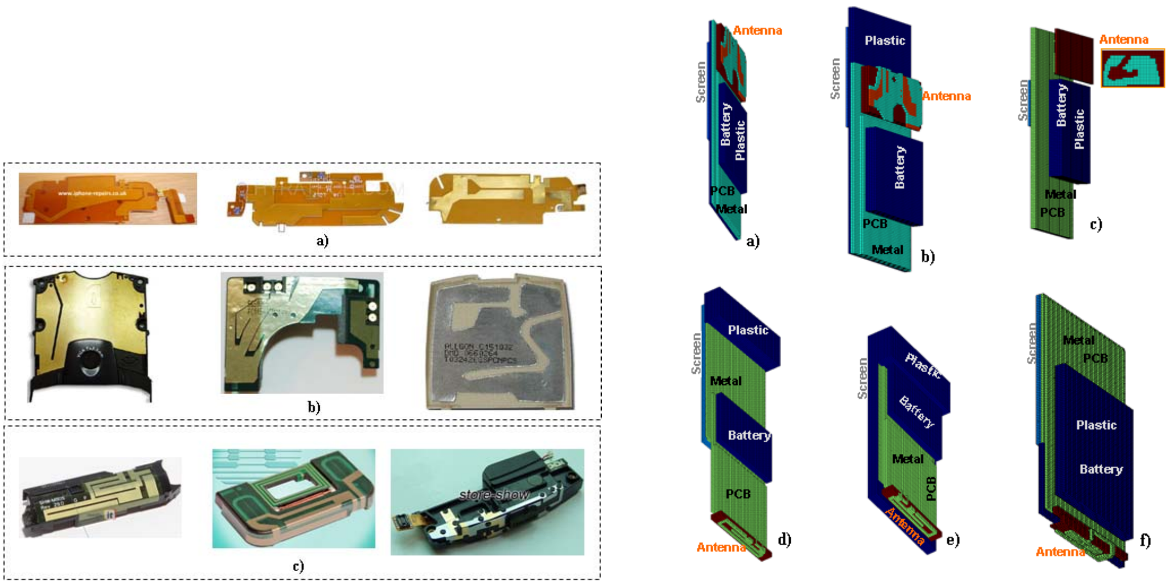


Figure 3. Antennas of mobile phones – Numerical models

The modeling for both slide phones takes into the main elements that can influence the antenna performances (radiation characteristics and impedance matching), and consequently the SAR exposure. In this way, the casing, the frame, the screen, the PCB and the battery have been considered in terms of equivalents electrical characteristics and dimensions.

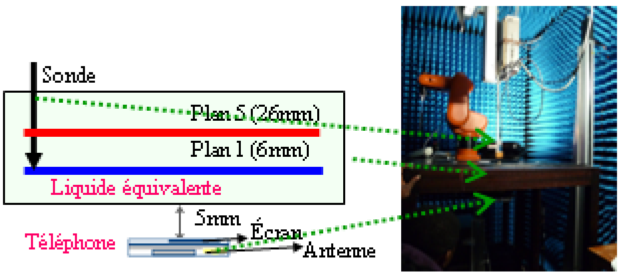


Figure 4. : Measurement protocol

Figure 5 displays SAR distribution measurement results from three mobile phones with different antenna positions. These results show the SAR distribution depending of the antenna position. It is observed the maximum energy concentration on the antenna side.

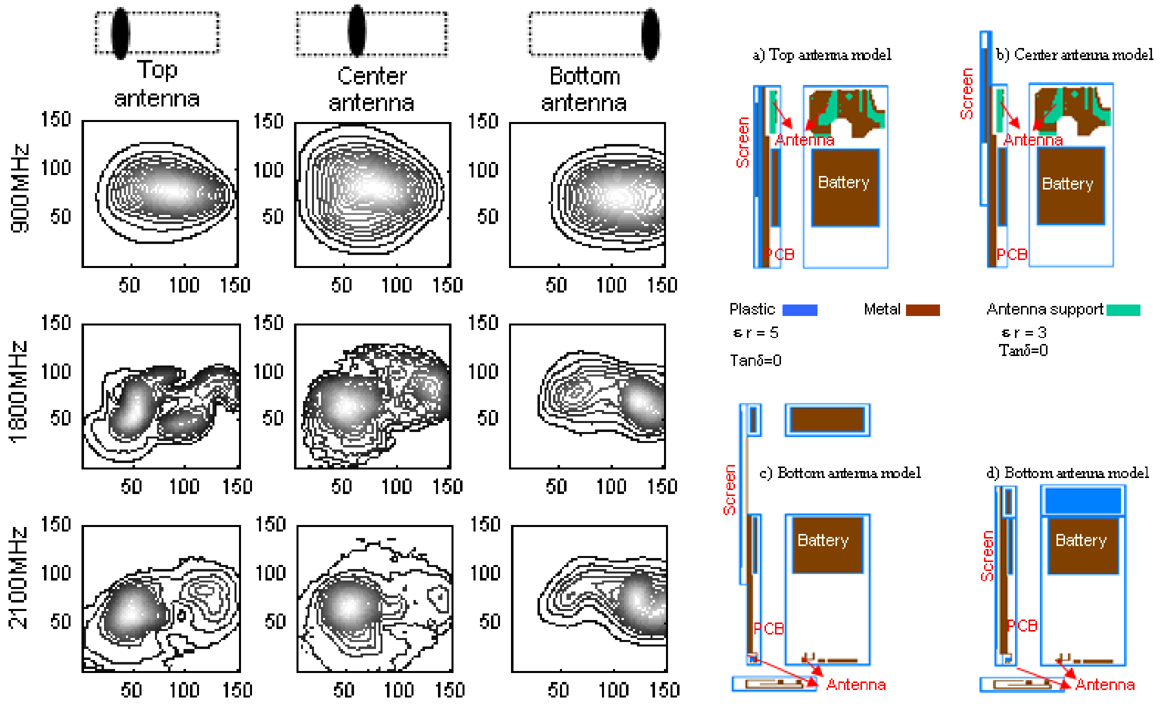


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Figure 5. SAR distribution measurements depending on mobile phone configurations - Mobile phone models

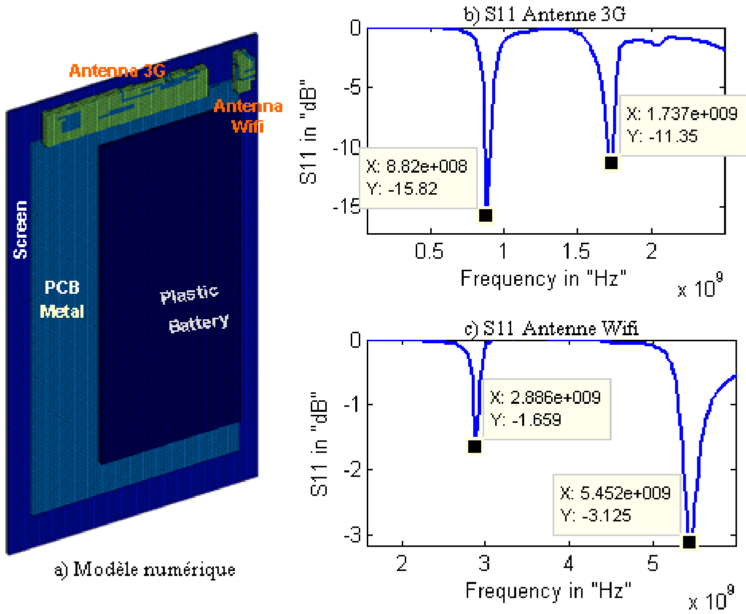

Figure 6. Tablet numerical model and simulated response (return loss)

The different configurations have been applied to various scenarios, selecting various sources (mobiles phone, tablets, computer,…).

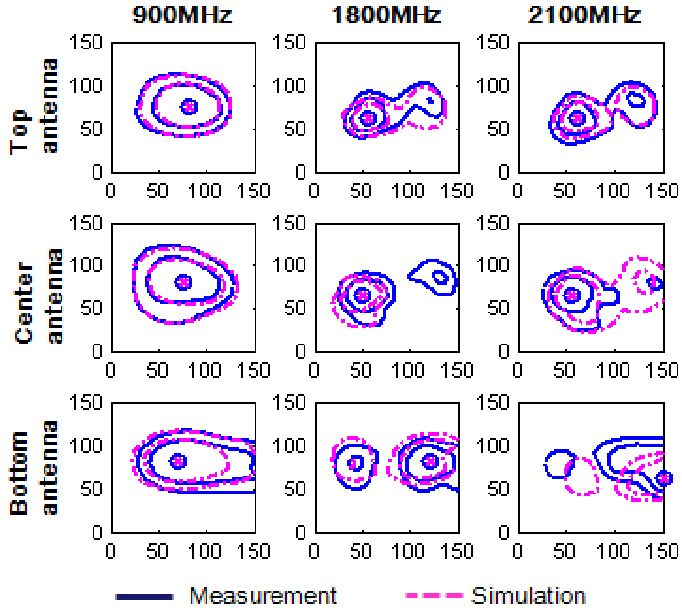

Figure 7. SAR Distribution from mobile phone models – comparison simulations/measures

The presence of the hand has been also considered with this model, through a collaborative work with Orange labs. Finally, these models can now be used in simulation to estimate specific absorption rate in sensitive anatomical regions (brain, genital organs, fetus, etc). They have been proposed to Telecom Paris tech for interfacing them with 3D imaging models.

Some of theses models have been also transmitted to the japans partners (NICT, Chiba univ), and the next meeting in Japan will be a good opportunity to share and compare experiences and models.

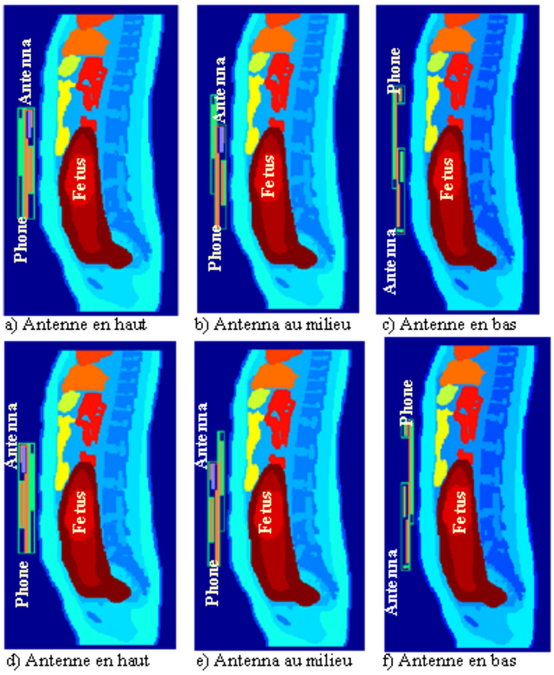

Figure 8. Abdomen with a fetus exposed to mobile phones

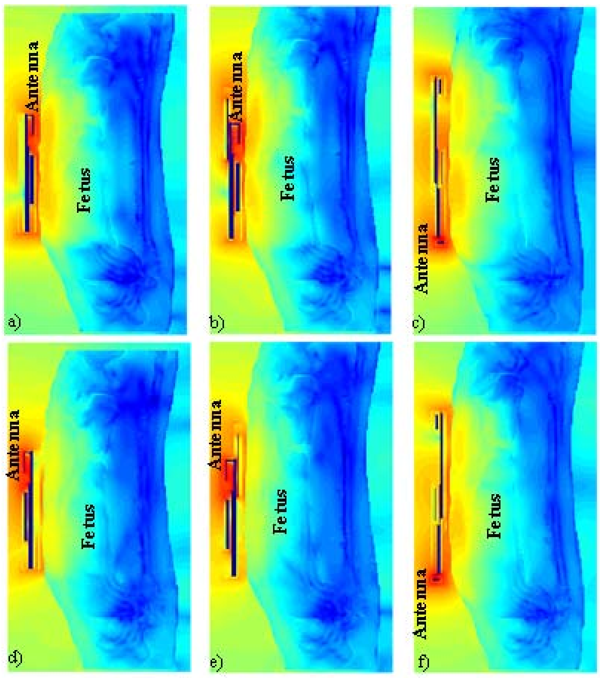

Figure 9. E-fields distributions within the abdomen with a fetus inside – Mobile phone exposure conditions