Abstract

Magnetic resonance MRI is an advanced medical imaging technique used to scan the body of a patient to discover abnormalities in soft tissues and bones. The preparation of the MRI room consists of several interconnected phases: fabrication and installation of the radio frequency (RF) cage, leveling the room floor, preparation of the quench pipe and safety exhaust fans. The preparation of the floor is very critical for the obtaining image quality. The floor should be leveled to minus 20-25 cm from the initial zero position with no tolerance. Thereafter, a magnet of 1.5 Tesla or more can be fixed. A small deviation in the leveling can cause noises to the magnetic vector and affect the diagnostics. Hence, the image can be distorted and produce incorrect diagnosis and treatment.

Due to the importance of the subject, precision needs to be achieved during construction. We offer to level the MRI floor using a lightweight-scraping robot. Leveling algorithm is divided into four steps:

- The cycle is reached by regulating the moving speed of the robot and the depth of the scraping edge with reference to the smoothness of the ground using Fuzzy logic rules.

Keywords: MRI, ground leveling, scraping robot

1. Introduction

In the last decade, the development occurring in material technology has led to a revolution in the conceptual design of machinery and electronic devices. Nowadays, for instance, a mobile phone is equipped with a variety of Nano-electromechanical sensors and actuators, OMLED screen, connection to navigation systems... the obtained product has pushed the end-users to ask for improved system specifications allowing better mobility. From a technical point of view, the customers are seeking a device with a better connectivity, allowing more independency, precision and versatility. The same tendency is generalized for several technological products: airplanes, medical devices, and office automation... As result, we obtained new classes (generation) of intelligent products to satisfy the needs of the market.

Concerning the medical field, advanced technologies such as robotics are being used to facilitate the medical-staff work and allowing them to concentrate on the life-saving tasks. For example, we have surgical robots, pneumatic transport systems, advanced imaging systems and drugs dispensers. But to make these systems work efficiently, an infrastructure should exist in the hospitals.

In this paper, we study the preparation of a magnetic resonance imaging (MRI) room from construction point of view. In order to achieve better image quality, the leveling of the room will be executed using a scraping robot. This will allow us to obtain no deviation of the floor leveling, which will minimize the effects on the magnetic vector.
2. Robotics for site preparation

Robotics aim to substitute men in dangerous tasks, as well as when infinite precision is needed. For example, miniature unmanned aerial vehicle where used to perform radiation leakage tests at hospital [1], check flyovers [2] and building facades [3]. Concerning related work to our topic, other designs of robots were found to laydown interlocks as shown in figure 1 [4], to assemble bricks [5], to check the tiles and concrete leveling [6,7].

![Robotics for site preparation](image1.png)

Figure 1. The brick-road laying TIGER STONE

Automating concrete paving shows to be cost-effective and time saving process than the conventional manpower approach. The gain by adopting the automated process can reach 21.3% by laying 26,600 bricks more then the conventional method in 500 controlled run hours [8]. The technologies used for robots autonomy vary from using machine vision as in [2,3], detection of prism position or guidance with GPS and Lasers as in [9].

The GPS is not accurate enough for indoor applications; in fact the signal can be lost. The prism detection and position scanning requires prior setup, which maybe time consuming depending on the status of the work site. The machine vision based guidance system is more adequate. Another way to achieve autonomous movement of the robot is using mechanical odometry. This allows to calculate the crossed distance by referring the rotation of the robot wheels. This method is more cost effective and easy to implement.

3. MRI- room preparation

3.1. MRI room construction concept

The minimum required area for an MRI room is 64 m² with a minimal height of 3 meters. The room should not be crossed by power cables or metallic constructions and should not be surrounded by dynamic metallic agents (cars, lifts), power generators (electrical/ pump rooms). The minimum distance of the disturbance to the magnet is 10 meters and may increase depending on the weight and rate of the source. The room inside is covered by radio-frequency cage to a height of 2.7 meters as shown in figure 2. All the necessary medical gas and electrical power is terminated to special filters.
The floor of the MRI room is leveled between -20 to -25 mm from the initial zero position of the concrete level depending on the type of the magnet. Nowadays, MRI use artificial magnet with 1.5-3 Tesla.

### 3.2. Floor leveling

The concrete floor is leveled to the required position in different ways worldwide. Although the results are satisfactory, there is a need to automate this task to avoid any possible human error, which may affect the image quality later. A scraping robot can be used to level the wet concrete as shown in figure 3.

By adjusting the scraper, the cement is pushed forward to a vibratory roller, which by its turn transfers the concrete to a sliding channel (chute) allowing the cement to fill lower gaps appearing during leveling. An applicator is used to keep the concrete wet enough to be manageable to work with.

### 3.3. Control concept

The efficiency of the scraping robot is achieved when all the mechanical modules work in harmony according to a predefined speed. In this way, the roller has the necessary time to fulfill the subtask and pass the excess cement to the chute. In this part we will study the scraping mechanism.

The scraper consists of a rigid working element (wide blade) responsible to push the concrete by adjusting the penetration depth. Controlling the amount of the scraped concrete is proportional to the inclination angle of the blade [10]. Literally, the blade acts like a plough in a farming terrain.

The control process is incremental in discrete time $T_s$ as an ordinary PI regulator. The inputs of the controller are the normalized error $N_e$ and its variation in time $D_e$. The later is required to take preventive actions and calculate the output of the regulator $O$. The architecture of the controller is shown in figure 4.
Using error values from conventional PI regulator, we have selected 7 membership functions (figure 5) varying between large, medium and small negative (LN, MN, SM), Zero (Z) and large, medium and small positive (LP, MP, SP).

The simulation results have shown that ideally, the scraper can regulate the angle so the concrete level can reach -20 mm from the initial zero position. The simulation results are represented in figure 6.
4. The verdict

Although the results obtained are satisfactory, the performance of the scraper is proportionally dependent of the shear stress of the soil. It is the force per unit area experienced by a slop (formed by the cutting edge of the scraper) which pushes the concrete along the failure plan. This force is directly related to the humidity factor of the concrete, hence the importance of the applicator. The interaction between the soil and the blade depends on how each mass of divided soil sector will express force of resistance.

As it is shown also, depending on the simulation parameters, the scraper required 80 seconds to infiltrate the concrete with a depth of -20mm. Hence the robot cannot start moving before the obtained process time, otherwise there will be depth deviation between different clusters.

Our future work will be related to modeling different types of soils and study their effects on the scraper.

References