（様式課程博士３）

学 位 論 文 の 要 旨

専　攻　名	環境工学	ふりがな 氏　名	ムスリ　ニザム　ビン　ヤハヤ MUSLI NIZAM BIN YAHYA 印
学位論文題目	Development of practical systems to identify material surfaces and dimensions using photograph images for room acoustics parameters (室内音場評価のための材料同定・幾何性状計測システムに関する研究)		

This study proposes a practical technique to identify surface material and dimensions for simulating room acoustics parameters e.g. reverberation time. The surface materials and dimensions are obtained from System 1 and System 2, each of which uses photographic images.

The study on System 1 uses a Gray Level Co-occurrence Matrix (GLCM) and a Feed Forward Neural Network (FFNN) to identify material surfaces. By identifying material surfaces, absorption coefficients of materials are also determined. Six types of material surfaces such as a wall, a door, a floor, a window, a ceiling and a carpet taken from Oita University rooms are employed. They are captured by using an ordinary camera which is a digital single-lens reflex (DSLR) with 50 mm and f2.8 lens. The total number of images captured are 36 with the proportions of images are as follows; surface wall = 69 images, surface door = 71 images, surface floor = 66 images, surface window = 56 images, surface ceiling = 67 images, and surface carpet = 40 images. Subsequently, all the images are computed in GLCM to obtain four Haralick coefficients; contrast (cont), correlation (corr), angular second moment (ASM) and homogeneity (hom). Haralick coefficients are referred to as coefficient values in this study are too wide to be processed because of variations of brightness and texture features. To overcome this problem, a limitation for each coefficient value is made $(\bar{x} - \sigma)$ and $(\bar{x} + \sigma)$ respectively, for a low limitation and a high limitation. The limitations of these coefficient values are represented in FFNN as input neurons and for the output neuron they are type of material surfaces. By identifying the material surfaces, we are able to ascertain the absorption coefficients of surfaces simultaneously. The results indicate that a good correlation coefficient $R \geq 0.90$ with $MSE \leq 0.07$ are provided by System 1 to identify material surfaces.

System 2 uses a Dimension Vision Predictor (DVP) with the author's "ruler methods" to identify the dimensions of objects. With similar camera used in System 1, two images are necessary to capture one view. The view of the images displays the ruler and objects to be measured. A ruler is used for standardizing the scale of the objects in the images. Subsequently, both images are fed into DVP to identify the object dimensions. The objects that need to be measured are marked with the corresponding points. To measure one dimension, two corresponding points are connected to make a single line. From the line, DVP identifies the dimension. To investigate the repeatability of System 2, examinations are conducted using 100 objects. The results reveal that the System 2 is highly capable of identifying object dimensions with correlation coefficient $R \geq 0.90$ and $MSE \leq 0.07$. From the results, System 2 shows that it has the potential to identify object dimensions.

（注）和文 2,000 字又は英文 800 語以内　　　　続紙　有■　　無□

A FFNN technique for estimating room reverberation times is developed. 700 samples of reverberation times obtained using Finite Element Analysis (FEA) are used for FFNN learning processes. In addition 35 unseen data are implemented to confirm the capability of FFNN estimation performance. The results indicate FFNN provides high correlation coefficient $R \geq 0.90$ with $MSE \leq 0.0004$ s. To investigate the reliability of FFNN, three conditions in an actual room are created. Reverberation time estimation by FFNN is compared with reverberation time by FEA and reverberation time by measurement. From analysis, MSE between reverberation times using measurement with reverberation times using FFNN are more than 0.002 s. On the other hand, MSE between reverberation times using measurement with reverberation times using FEA are more than 0.005 s.

A series of measurement in four practical rooms using both systems are conducted to investigate identification capability are conducted capability of the systems. An examination of System 1 verified a good correlation coefficient $R \geq 0.90$ with $MSE \leq 0.07$ s. Meanwhile, System 2 yields a high correlation coefficient $R \geq 0.90$ with $MSE \leq 0.2$ s. Finally, reverberation times for four practical rooms were conducted by using FEA with the important parameters obtained from System 1 and System 2. Sufficient agreements were exhibited by comparing the reverberation times obtained by FEA using both Systems (RT_{FEA} system) with reverberation times obtained by FEA using actual absorption coefficients and dimensions (RT_{FEA} actual). They yielded practical results with correlation coefficient $R \geq 0.85$ with $MSE \leq 0.008$ s.

In conclusion, a practical technique to identify surface materials and dimensions using photographic images yielded practical results. With some improvements such as adding more Haralick coefficients and standardize room illumination, the techniques will be more accurate, effective and practical when applied in the actual rooms. Furthermore, it is useful for simulating room acoustics parameters such as FEA, BEA, Ray tracing and so on.

（様式課程博士８）

学位論文審査結果の要旨

専　　攻	環境工学　　専攻	氏　　名	Musli Nizam Bin Yahya
論 文 題 目	Development of practical systems to identify material and dimensions using photograph images for room acoustics parameters （室内音場評価のための材料同定・幾何性状計測システムに関する研究）		
主　　査	大鶴　徹		
審 査 委 員	真鍋　正規		
審 査 委 員	秋田　昌憲		
審 査 委 員	小林　祐司		
審 査 委 員	富来　礼次		

審査結果の要旨（1000 字以内）

Sabine 等の残響式やコンピュータシミュレーションを利用する室内音響評価において、建築境界の複雑雑多な形状と吸音特性を的確に把握する手法の開発が望まれてきた。

本論文は、画像処理とニューラルネットワーク技術の活用で建築空間の表面材料の吸音特性と座標を効果的に測定する２つのサブシステムを開発し、その精度と再現性の検証を行い室内音響の効果的な評価の基盤としたものである。

まずサブシステム１として、デジタル画像へ Grey Level Co-occurrence Matrix と Feed Forward Neural Network (FFNN) を適用し材料同定を行う手法の提案を行った。この手法は、Haralick's coefficient の利用により FFNN による同定を可能とし、同定した材料へ既存データベースの吸音特性を割り当てている。その精度の確認のため本学講義室を対象とする予備実験を実施したところ、光学的に反射性材料について同定精度が低下する傾向が確認された。その改善に関し試行実験で得られたデータをもとに FFNN による検討を行い、入力データの正規化処理が同定精度を大きく向上させることを見出した。この前処理手法を採用したサブスステム１に関する同定精度の検証実験において、材料の想定値との相関係数が 0.99 以上、吸音率の想定値と予測値の平均自乗残差が 0.07 以下、という良好な結果が得られその有効性が確認された。

続いてサブシステム２について、ステレオ画像から部材の座標値を推定する手法の提案と有効性の検証を行った。この手法は、建築室内空間の現場測定において有効な Ruler Method と称する新たな手法を提案した上で、既存の Dimension Vision Predictor を組込むもので、３D レーザー計測手法等に比し後処理の簡略化を実現している。本学講義室内 100 点を対象に、座標値測定の精度と再現性に関しレーザー測定結果を真値として比較し、相関係数が 0.99 以上、平均自乗残差が $0.07m^2$ 以下と十分な近似と再現性が確認された。

最後に、これら２つのサブシステムで収集した材料特性と室形状を、本学開発の有限要素法による残響時間シミュレーションへ入力したところ、理想値との相関係数が 0.85 以上、平均自乗残差が $0.01s^2$ 以下という十分な近似が確認された。

以上、本論文は建築学分野における新規性、有用性、信頼性がいずれも高く、さらに公聴会での質疑応答の的確さをあわせ、学位論文に値するものと判断した。