論文 / 著書情報
Article / Book Information

題目(和文)	
Title(English)	Mass Spring Models for the Simulation of Deformable Objects
著者(和文)	MACIEJ KOT
Author(English)	Maciej Kot
出典(和文)	学位:博士(工学), 学位授与機関:東京工業大学, 報告番号:甲第9660号, 授与年月日:2014年9月25日, 学位の種別:課程博士, 審査員:長橋　宏,熊澤　逸夫,小池　康晴,中村　健太郎,山口　雅浩
Citation(English)	Degree:Doctor (Engineering), Conferring organization: Tokyo Institute of Technology, Report number:甲第9660号, Conferred date:2014/9/25, Degree Type:Course doctor, Examiner:,,,,
学位種別(和文)	博士論文
Category(English)	Doctoral Thesis
種別(和文)	論文要旨
Type(English)	Summary

（博士課程）
Doctoral Program

論 文 要 旨

THESIS SUMMARY

専攻： Department of	Information Processing 専攻	申請学位（専攻分野）： Academic Degree Requested	博士 Doctor of (engineering)
学生氏名： Student's Name	Maciej Kot	指導教員（主）： Academic Advisor(main)	Hiroshi Nagahashi
		指導教員（副）： Academic Advisor(sub)	

要旨（英文 800 語程度）
Thesis Summary (approx.800 English Words)

This thesis investigates properties of mass spring models for the purpose of the simulation of deformable objects for Computer Graphics. The underlying theory is closely related to that of the theory of elasticity for solids or fluids. We have explored the limitations of simple (ordinary) mass spring models and formulated a methodology for constructing the mass spring models with well-defined physical properties. In particular, we emphasized the importance of isotropy of the models and the limitations it places on the geometry of the network. Next, we have discussed the classical result of the theory of elasticity that while any value of the Young's modulus can be obtained by tuning the spring coefficients in the network, the value of the Poisson's ratio is constrained to be 1/4 (in 3D). Finally, we have derived a simple formula, linking the Young's modulus with the mean value of kL^2 throughout the network, where k and L are the spring stiffness coefficient and its length, respectively. This is a relatively simple and yet general formula, which can be applied to virtually any MSM and does not require a complicated analysis of the model. Next, we extend our models to represent materials with other values of Poisson's ratio as well. By introducing an extended force interaction mechanism we can achieve a plausible behavior for a wide range of materials.

We have analyzed two approaches of creating MSMs. First one assumes mass point distribution on a cubic lattice. Second approach is based on random node placement. The tests in which we measure the elastic properties of both cubic and random lattices show that our models agree satisfactory with theoretical predictions and thus are well suited for the modeling of elastic materials. The random MSMs seem to perform almost as good as the cubic ones when the global deformations of the system are concerned, but slightly underperform at the smaller scales (of the order of few internode distances). Even though the difference is not large, it does show that MSMs, particularly low resolution ones, require attention during generation process in order to minimize discretization errors. Overall, however, the performance of random models is good enough for them to be an attractive alternative to the cubic models, as in many situations a slight decrease of accuracy may be an affordable price to pay for the flexibility of choosing node positions. Additionally the proposed antialiasing method allows for refining cubic lattice mass spring models. Mass and stiffness of each element are adjusted according to the fraction of the volume overlapping with reference shape. Step-like features that normally appear in cubic lattice MSMs can be greatly reduced by this technique, allowing to model non trivial shapes even with relatively low resolution latices, while preserving their physical properties. Improvement of the behavior of antialiased models is significant compared with the standard MSMs.

Mass Spring Models presented in this work, can be treated as a means of representing elastic objects. They provide a correct mapping of elastic properties between a physical object and a model is a prerequisite for any physically correct simulation, be it quasi-static or dynamic. The examples of the simulations with explicit time integration technique shows, that these models behave correctly under various circumstances and that their properties do not change drastically with the change of resolution. We were able to achieve a consistent collision and friction responses for modeled objects.