Title

Nutcha Chayanurak

Abstract—

I. INTRODUCTION

II. PREVIOUS WORK

This section reviews previous methods for the simulation of melting and freezing phenomena. Kim et al.[1] presented a hybrid algorithm for generating the ice crystal growth by the thermodynamics. Although this method cannot handle thick features, such as icicles, they also proposed a method for simulating icicle formation by solving the thin-film Stefan problem[2]. Madrazo et al. started integrating air bubbles into ice[3]. Their method simulated a dissolved air exhausted from water-ice interface to create geometrical representations of ice with bubbles. Nishino et al.[4] improved method for calculating the sizes of air bubbles taking into account pressure and freezing velocity. Miao and Xiao[5] presented particle-based ice freezing model to simulate the fast freezing phenomenon occurs in flowing water. This method improve the visual detail of ice appearance and can create convincing freezing ice results except in violent fluid movement.

Iwasaki et al.[6] proposed a particle-based simulation method for the heat transfer and interactions between fluid and ice. They improved a simple method for the interfacial forces between water-ice particle to simulate the flow of meltwater on ice and the formation of water droplets. Although this method can be applied to the simulation of water freezing, it was not further studied. Domaradzki and Martyn[7] proposed new particle-based air model represents the natural air convection on the ice melting process which allows for considering local changes in air temperature and a new external heat source model controls direction of the ice melting. Lii and Wong[8] proposed new attribute called virtual water for ice particles. Their approach also handles the transition between the virtual water on ice surface and the water particles and computes the density field defined by the ice particles and the virtual water.

III. METHOD

IV. RESULT

V. CONCLUSION

VI. ACKNOWLEDGEMENT

REFERENCES

[1] Theodore Kim, Michael Henson, and Ming C Lin. A hybrid algorithm for modeling ice formation. In *Proceedings of the 2004 ACM SIG-GRAPH/Eurographics symposium on Computer animation*, pages 305–314. Eurographics Association, 2004.

[2] Theodore Kim, David Adalsteinsson, and Ming C Lin. Modeling ice dynamics as a thin-film stefan problem. In *Proceedings of the 2006 ACM SIGGRAPH/Eurographics symposium on Computer animation*, pages 167–176. Eurographics Association, 2006.

[3] Carlos Madrazo, Takeshi Tsuchiya, Hiroaki Sawano, and Keiichi Koyanagi. Air bubbles in ice by simulating freezing phenomenon. *J. Soc. Art Sci*, 8(1):35–42, 2009.

[4] Takanori Nishino, Kei Iwasaki, Yoshinori Dobashi, and Tomoyuki Nishita. Visual simulation of freezing ice with air bubbles. In *SIGGRAPH Asia 2012 Technical Briefs*, SA '12, pages 1:1–1:4, New York, NY, USA, 2012. ACM.

[5] Yunbin Miao and Shuangjiu Xiao. Particle-based ice freezing simulation. In *Proceedings of the 14th ACM SIGGRAPH International Conference on Virtual Reality Continuum and Its Applications in Industry*, VRCAI '15, pages 17–22, New York, NY, USA, 2015. ACM.

[6] Kei Iwasaki, Hideyuki Uchida, Yoshinori Dobashi, and Tomoyuki Nishita. Fast particle-based visual simulation of ice melting. In *Computer Graphics Forum*, volume 29, pages 2215–2223. Wiley Online Library, 2010.

[7] Jakub Domaradzki and Tomasz Martyn. Improved particle-based ice melting simulation with sph air model. 2014.

[8] Shing-Yeu Lii and Sai-Keung Wong. Ice melting simulation with water flow handling. *The Visual Computer*, 30(5):531–538, 2014.