PDF - A BIO-INSPIRED GROUP EVASION BEHAVIOR - researchcub.infoGroup evasionbehavior is the evasion pattern of numerous agents, one kind of the mostfrequently observed behavior patterns in nature. However, there appears to berather little research about human crowd evasion behavior. In this paper, Iintroduce a new model for simulating group evasion behavior based on biologicaland sociological models for the purposes of simulating the crowd animation inevasion situations. In biology, fish school group evasion behavior is wellstudied and it has a possibility that the human crowd evasion behavior inemergency is similar to fish school group evasion patterns. I take thisbiologically inspired model and seek to extend it by integrating sociologicalfactors found in human groups. For the immediate dangers, bio-inspired modelcould simulate human evasion movement. With sociological factors, I cansimulate more complex evasion patterns with considering sociological factors.With this model, I would be able to simulate crowd evasion behavior inemergency situations. Introduction: The collective behavior of human crowds isone of the most interesting topics for numerous researchers and research areassuch as sociology, virtual reality, computer graphics, robotics, psychology,politics, transportation, etc. However, it is difficult to simulate crowdbehavior with a good mathematical model because many factors influence how eachindividual will behave and affects the overall crowd behavior. The factors thatinduce a variation of a person’s behavior are physical attributes, personality,social status, relations with other individuals, etc. These factors makescientific experiments very hard, and generate difficulties for validation.There are various models to explain human crowd behavior in sociology andpsychology [27, 28, 29, 32], but none of them is proven because of thepreviously mentioned difficulty in the modeling and the validation. Moreover,we cannot experiment on human crowds to produce collective evasion patterns, soit is difficult to retrieve relevant data. Also, collective evasion patternsare usually expressed in emergency situations, so few pieces of video data forthis behavior are available. 1. Previous works in crowd simulation and motionplanning Crowd simulation and multi-agent motion planning have been studied bymany researchers. One of the main research topics in robotics is to enablemulti-robot agents to navigate autonomously and collision-free in variousenvironments. In computer graphics, motion planning with autonomous agentscould be used for digital actors, which can react and adapt to high leveldirectives in dynamic environments. Navigating in dynamic environments [2, 3,4, 6, 8] and efficient collision avoidance [1, 5] for numerous agents are maintopics for multi-agent motion planning. Crowd simulation is very difficult notonly for the multi-agent motion planning problem, but for the inherentcomplexity in the behavior of each human individual. For the purpose ofhandling very large number of agents, there are two major approaches for crowdsimulation modeling; considering the crowd as particles or considering thecrowd as a large group of agents. The particle approach for the crowd modelingis based on a continuum perspective for the crowd, which considers crowd assome continuous material. It considers crowd motions as per-particle energyminimization [5, 8, 14]. Because the system controls all the particlesentirely, all the individual motions could be guided easily by global motionplanning. Also, it is quite efficient for computation, because increasing thenumber of agents is just condensing the density of particles. However, becauseit is based on continuum perspective, the motions of individuals are similar tofluid and not quite realistic [5, 14]. The multi-agent approach for crowd modelingis much more complex than the particle approach. The complexity of themulti-agent motion planning increases exponentially with the number of agentsand their degree of freedom. However, with this model, each agent can reactwith some intelligence, similar to the real world, so we can control eachagent's movement more precisely with more details and with autonomousnavigation capabilities [2, 3, 4, 6, 8]. Within various group behaviors, thecrowd evasion behavior is useful for numerous applications: animation,simulation, social science, virtual reality for various situations: evacuation,police chasing to arrest the riot or protester situation, minimizing damage interror situation, escaped animals from zoo, controlling disorder situation, orvideo games. There is some good research on crowd evasion situations evacuation[9], and suicide bombing terrorist [11]. Helbing presents collective crowdbehavior of evacuation, induced by panic, using a simulation based on a socialforce model. He considered the social force with psychology information, andsimulates group evasion patterns resulting jamming in life-threateningsituations. Zeeshan shows that running to an exit exposes a person to deaththreatening situation when the suicide bomber attacks the crowd. However, weare not aware of any works in crowd simulation about use of evasion behaviorsbased on biological models. 2. Bio-inspired algorithms It is a well developedapproach to introduce biological algorithms in various fields: optimization, robotics,networking, social organization, etc. In particular, robotics researchers aremainly focused on an emergent behavior of a biological swarm, which is ahigh-level goal-driven group behavior resulting from the cooperation of simpleindividual patterns. Emergent group behavior patterns are easily found asinsect swarm and animal herd behaviors in nature. Biological individuals onlyhave limited sensing capability, and use simple and robust decentralizedalgorithms. Biological algorithms are easily applied to simple autonomousrobots for these properties, so there are numerous bio-inspired researchstudies in robotics [17, 18, 20, 23, 24]. Because the biological algorithms orprocedures have survived the evolutionary process, they are shown by natural selectionto be effective, robust and efficient. Bio-inspired approaches are often usedwhen dealing with overly complex problems, or when there exist similar problemsin nature. Many researchers have used biological inspirations. Reynolds [15]simulates the flocking behavior inspired by flock of birds. Svennebring andKoenig introduce ant pheromones for their terrain covering robots. Schwager etal. bring in the ladybugs' algorithm to solve terrain coverage problem withdistributed agents [20]. Halasz et al. introduce the quorum sensing for theredistribution of swarm robots, which is inspired by ants' house huntingalgorithm [18]. Stafford et al. utilize the locust vision system in thecollision detection mechanism for cars [24]. Barrows adopts the optic flow toUAV flight control, which is used by insects' vision to avoid collision [23].The genetic algorithm and the ant colony optimization are used in numerousfields: game theories, NP complete optimization problems, etc [19]. However,there are few papers [15] in computer animations for group behaviors which arebiologically inspired. In emergency situations, human crowd reactions aresimilar to animal group behavior in a high level perspective, because of theurgency to react – “Individuals start pushing, and interactions among peoplebecome physical in nature” [9]. The reactions of people vary at the differentlevels of danger and situations [29]. However, with immediate dangers forprimitive sensors, people usually have no time to think about the complex environmentalinformation, so I believe that there should be some linkages between the crowdevasion behavior and the animal group evasion behavior. Therefore, adoptinganimal group evasion models should be useful to simulate the crowd evasionpatterns. Animal group evasion behaviors are well studied because it is one ofthe most important behaviors for animal researchers. Unlike the human crowdevasion behaviors cases, the experiment for the animal group evasion behaviorseasily controls variables, and generates repeatable situations. Therefore,animal researchers have developed good mathematical models for animal groupevasion cases. Especially, fish group evasion patterns are one of the bestdeveloped behaviors and have some good mathematical models with relevantevidence data [21, 22]. Among the fish group evasion behavior models, Inada etal. [21] suggest a good mathematical model with the validation of simulationand proper proof. Its basic model is based on Aoki’s and Huth & Wiseel’smodel. This model is based on individual behaviors, so it is proper to generateemergent behaviors. It is two-dimensional model based on velocity and angularchange with decision time delay also being considered. The decisions of fishindividuals are based on motions of neighborhood, with some tendency value. Thebasic strategy for grouping is similar to Reynold’s flocking [15]. Fishindividuals move during building a group with motions of approaching, parallelorientation, and repulsion. With this model, the authors could simulate allreported evasion patterns of real fish schools, except for the ball pattern. Itis a good model with reliable validation data, but has some limitations. Theirmodel only considers free field with no obstacles, and only one predator. Also,they do not think about the factor of domains of danger [25] or the speedchange for urgent evasions.

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