

Master Of Magic Tactical AI

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1 AI weaknesses in the original game

Currently I've identified several weaknesses of the game's combat AI. These weaknesses apply to all AI in combat, regardless of the selected level of challenge, school of magic, etc. Long story short, the AI is very predictable.

1. Easily the worst: AI has just one target unit selection strategy. The AI always targets the weakest unit on the battlefield, measured by defence or hps, regardless of its other abilities, and keeps attacking it, until it's dead. This means that AI most likely uses only defence and hps of the target for decision making. This makes the AI very predictable, as it's fairly easy for the player to trick it into wasting its units and mana on the player's weak units.
2. For example, Player has 2 units, one with defence of 1 and attack of 1, the other has defence of 2 and attack of 100. Obviously the latter is more dangerous, and almost just as weak, and should be dealt with asap, but that won't happen until the former one is done away with. Personally, I just keep summoning very cheap Phantom Warriors, which the AI keeps targeting, until it runs out of mana and strong units.
3. Another example: two identical units, one with 1/8 figures, the other has 8/8 figures. Again, the AI should be targeting the latter, because its attack is much higher, but, on the contrary, its attacks are directed towards the former, until it's dead.
4. AI units always follow the shortest path to the designated target (A* pathfinding, I believe), ignoring all other factors or threats. This makes the exploitation of the AI units' weaknesses an easy task.
5. AI always use actions and moves units in the exact same order, regardless of the situation on the battlefield: wizard's spells → unit spells → ranged

attacks \rightarrow unit movement \rightarrow melee attack. This exposes another weakness of battle mechanics: a unit with both melee and ranged attack, cannot choose the type of attack. It keeps using ranged attacks until it expends them all, also disregarding the distance to the defending unit. This is a serious weakness, especially for units which melee attack is much better than ranged (e.g. Nightmares).

6. AI keep casting spells every turn, until it runs out of mana.
7. Consequentially, the player always knows quite well ahead, what to expect from the AI. In other words, there are certain actions that the AI just doesn't have in its 'basket', such as retreating. In fact it always stupefied me, why the AI doesn't retreat when the odds obviously are tipped against it.
8. This applies even to cases, when a unit has a specific attribute or ability in its 'basket', and it doesn't make any sense at all. For example, range penalty for normal ranged attacks. I never saw AI ranged units reduce the distance to the enemy lines, in order to increase the damage, instead, they just stand still and keep shooting. Another example, is that the besieged AI starts moving units, when it's obvious that they have much higher survival chances staying behind the city walls.
9. Most importantly though, it doesn't feel like AI commands an army, as tactical decisions are made at unit level.
10. Putting that all together, AI battle mechanics is rather simplistic and predictable.

There are, of course, exceptions, such as battlefield enchantments, but this doesn't affect the cases above. Hence, I introduce suggested changes in three stages:

1. Strategic level (overall)
2. Tactical level (turn-level)
3. Unit maneuvering (melee)

2 Ideas for improving the AI's combat strategy

I believe that this simplicity is explainable by the lack of fast numerical approximations to combinatorial problems, like bipartite matching, travelling salesman,

knapsack, shortest path in a graph, etc, back in '94. At present, there are many fast solutions, like water flow-like method that solves TSP for 200 vertices in 15-30 seconds. I think 4X players would agree to wait for 15s between turns, considering the payoff. A solution like this would probably feel like playing against a very beginner AI chess player, but for a 4X game it should suffice.

Here are some basic considerations for the improvement of AI at the strategic level, affecting the whole battle:

1. AI should adjust its strategy to the type of combat. For example, when defending vs attacking vs siege. Clearly army composition and terrain would be key factors here (see below). At present it's just pretty much two armies attacking each other. IRL when the army defends, it wouldn't just rush to assault the enemy. Instead it would 'dig in' and see how things go. The attacker would probably follow a 'mirror' strategy, that is, actually move towards the AI and see how things go.
2. AI should vary from challenge to challenge (easy to extreme). Assuming some kind of tree-like algorithm used for decision making, it shouldn't be too hard to limit the number of leaves in the tree. The higher the challenge, the deeper the tree.
3. AI should vary from race to race, and from unit to unit. Obviously, Elven Lords have greater intelligence than semi-sentient Klackons' Stag Beetles coordinated by a hivemind, or Lizardmen Dragon Turtles. The latter two can just stick to the current AI, while the former could use more sophistication (see below).

All of the above only concerns AI strategy in combat, that could tailor the AI decision making to a particular type of battle, instead of one-fits-all approach. Behaviourwise, it will manifest itself in more varied tactical solutions (Section 3) and unit maneuvering (Section 4).

Although some of these ideas have been already implemented in other TBS/4X games, but they typically suffer from a range of serious flaws, which can be, generally, of two kinds: either very simplistic, or too unwieldy. Unlike them, MoM has the right number of features (see the other file for an in-depth discussion), making the numerical solutions above feasible.

Specifically, both normal and fantastic units have at most 5 main attributes (melee, ranged, defence, hps, resistance), 4 base abs (movement points, movement type, attack/defence success chance) typically at most a couple of unit-specific abs of buffs (cast spell, +N to attack, special attack, etc), and typically at most a couple of enchantments or curses. There are a total of 34 unit enchantments across all schools of magic, and 10 unit curses, and 54 special unit abs, and the order of melee stack resolution (thrown \rightarrow breath \rightarrow ... \rightarrow melee) is always the same, as well as attack/counterattack protocol.

Factoring in all of the above, AI should be able to quickly evaluate the strength of both armies and make the (approximately) best strategic decision

3 Ideas for improving AI's tactical solutions

In this section, I would like to explain possible AI improvements, at the tactical level. Each of them can be traced back to one or more strategic ideas above. For better clarity and understanding, I grouped into several 'umbrella' terms. Of course, there are overlaps between ideas covered by these 'umbrella' terms, as explained below.

3.1 Main considerations

Of major importance though, is that combat itself should make sense, through the AI's evaluation of the current situation on the battlefield, at the army level. This is where I have to return to the feasibility of such solutions, but, again, unfortunately, I'm not an expert in fast numerical approximations to combinatorial problems, because each (or most) units' attributes and abs have to be considered. But, on the more optimistic side, see above for a relatively small number of features to be taken into account.

The key challenge, as I see it, is that every turn AI has to evaluate both armies in order to establish their overall strength and come up with a tactical, turn-level solution. For example, if this turn AI is under attack by many normal ranged units, it needs to decide whether to cast Guardian Wind on fast strong units, or pull them back. In the former case, it would opt for a more aggressive solution, perhaps charging straight into the enemy. In the latter, it would need to find a way to eliminate the line of sight (see below) and increase the distance from the ranged units.

And again, tactical solutions don't need to be globally optimal, but they have to be meaningful at least at turn level. AI can't make obviously suicidal decisions, or follow a rigid decision, e.g. attacking a particular enemy unit until it's done away with, regardless of the situation. On a battlefield with a 'simple' terrain and basic units, the solution space for turn-level decisions should not be very large (see on army size later), as each turn AI evaluates the overall strength of both armies, and uses it as the main input variable to construct tactical solutions, making the collection of units actually look like a real army.

For example, assume that there exist two simple overall strategies: maximize damage to the enemy or minimize AI damage, and the AI is following the former. So, based on the overall army evaluation, AI decides to maximize enemy damage given some set of constraints (e.g. take at most K expected damage, keep at least N units, etc). In case such solution is infeasible, it can relax some

of the constraint. In the worst case, it can just revert to some non-constrained solution, such as simply maximize enemy damage.

Now, let's map it to the ranged attack situation above. AI has to identify units for the attack, ranged support, spells, that would maximize the expected damage dealt to the player, the cost thereof, i.e., mana for Guardian Wind and other protection spells, expected losses, etc, and then prune the tree to arrive at the locally optimal solution, that involves the whole (or part) of the army, rather than separate units.

Now, I want to discuss some aspects with a heavy influence on the tactical-level AI.

3.2 Fog of War

This is an obvious must, implemented in, to the best of my knowledge, all other 4X/tactical wargames, particularly well in *Fantasy General*. Its effect on decision making of the AI and the player simply cannot be overstated. I can only list a few here:

1. Existing unit abilities: Scouting or Flying increases the visibility range,
2. Dispel FOW: perhaps Nature's Lore,
3. A new spell: summon (create) FOW to obscure units
4. Terrain: units on elevated areas have a higher visibility range (see below),

Consequently, both sides will strive to maximize their visibility area. I'll stop here, because it should not be a daunting task to come up with new effects of the FOW.

3.3 Terrain

This is another key factor in advancing the AI, explained by its comprehensive effect on the combat tactics, one mentioned above (visibility).

1. Unit (in)visibility/Line of sight (LOS): it is different to FOW above. LOS of the whole army is the union of the LOS of all its units, e.g. see *Total War: Attila*. LOS is affected by the elevations, walls, and similar barriers. Simple example: an enemy unit is behind a hill, and is visible to me. Nevertheless, there is no LOS between any of my ranged units and the enemy, due to the elevation. This disables any type of ranged attacks on it.
2. Unit (in)visibility/hiding: regardless of the FOW or LOS, units can have (in)visibility buffs related to the terrain. The obvious one, is invisibility in forest or similar tiles, or perhaps Nagas in river tiles. Note this is neither FOW, nor LOS, nor Invisibility ability, like that of the Nightblades. It's

a terrain effect, that is, the unit won't be revealed by dispelling FOW or gaining LOS, or Illusion Immunity. But, like in case of invisible units, they are revealed by moving adjacent to them. Obviously, this begs for some sort of ability to reveal and target units in this terrain (see below).

3. Unit abilities. This is not the same as combat mechanics below. Terrain-specific unit abilities can be split into two types:
 - Effect on the existing abilities, such as Forester: in addition to the existing effect, Longbowmen, for example, get +1 to ranged attack, when visible in the forest tile, and +2 when invisible in the forest tile, +1 to movement (main effect), and such. Then, by the mirror effect, there should be a nerf, like -1 to defence for certain units, e.g. large like Dragon Turtles, i.e. one defence shield goes dark. Similar ability could have units like Nagas, in water tiles like rivers. I mean, ambush Cavalry in a river crossing, what could be more fun than that? In my opinion, this is both exciting and easy to implement, because these novelties are manifested only in the increase or decrease of attack or defence.
 - New abilities, that are activated only in particular terrain tiles. One rather obvious thing is for Engineers to build bridges on river tiles. This ability would be useful on the overland map too, though.
4. Combat mechanics. Attacks by hidden units deal more damage, a lot of ambush attacks, using elevations for gain visibility and cut range penalties: this opens a lot of opportunities for using terrain for tactical maneuvering.

Another simple example: you managed to position Bowmen-1 on elevations, threatening the advance of AI Cavalry. Instead of charging head-on, they turn right and get close to the forest, where a unit of Bowmen-2 ambushes them, dealing a serious damage. Evaluating the situation, AI Cavalry decides to retreat to avoid further losses. Simple and elegant, right?

But, then your Bowmen-1 descend from the elevation to chase the unit down, losing the visibility and attack buffs, and are surprised by AI Pegasusai ranged attack. Bowmen-1 retreat to the forest, but forested tile invisibility buff does not apply to flying units, which quickly decimate the remaining Bowmen-1 with a ranged attack. Bowmen-2 unit manages to deal some damage in retaliation, but AI Pegasusai have the choice to either (a) finish the job by attacking Bowmen-2, or (b) retreat to minimize damage.

4 Unit-level AI

Disclaimer: The ideas expressed below use a melee stack that could be different from the one that actually is implemented in the version I have (1.52.03 Community Patch): the total raw damage dealt by a multifigure unit is a total number of successful attack rolls, and total blocked damage is the total number of successful defence rolls. Unblocked damage is applied to the unit starting with the top figure. In other words, a multifigure unit does a total of number of figures \times attack strength attack rolls and a total of number of figures \times defence strength defence rolls.

4.1 Main considerations

Low-level unit tactics can easily bog down in boring and repetitive micromanagement, hence, my ideas were motivated by the following factors:

1. Avoid micromanagement, in the sense used earlier: minor buffs/nerfs, varying from unit to unit or race to race. Keep it simple. This means, no new spells, abs, etc.
2. Avoid rigid formations, like in *Empire: Total War*. In that game, each unit (I think) has different formations. I don't know if it works in wargames, but we want to keep things the way they are as much as possible, yet add interesting new functionality.
3. Preferably avoid simplistic and/or obvious buffs. For example, two adjacent infantry units get +1 to defence. Or, attack from two directions gives the attackers a flanking bonus. Much of this has already been realized elsewhere, e.g. in *Fantasy General*.
4. The previous point, in my opinion, especially concerns functionality like overwatch or critical damage, which are a bit of lazy 'cheats', and should not be added to MoM, due to their triviality.
5. Only use existing MoM units' abs, combat rules, melee attack/counterattack and resolution stacks, figure-based attack/defence strength. These rules are unique to MoM, and we should make an even better use of them.

4.2 Unit maneuvering

I introduce two ideas for unit-level AI:

1. Split and merge multifigure units of the same type.
2. Put different units into a formation that attacks and defends jointly in a melee combat.

These ideas are valid both for the AI and the player, so I left their in-depth discussion in the combat mechanics file.