VIRTUAL HUMANS
FOR SERIOUS GAMING
FINAL REPORT

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1 Introduction

This project is build around the Tygron Engine; an urban planning 3D software product. It requires different stakeholders to work together in simulation of a map that represents a reallife location (within a city). This allows all parties to simulate how certain decisions might influence everyone participating. All planning is done in real time, which makes the simulation more realistic. However, this creates problems requiring every stakeholder to be physically present during the simulation. This is commonly done through Charretes [2]. To combat this problem we are tasked with designing and creating a virtual human, which simulates a real stakeholder by the use of artificial intelligence in a way so that it does the same actions the stakeholder would do. This virtual human should have a certain strategy and reasoning of why it acts the way it does. It is designed around a scenario created at the beginning of the project, but should be capable of acting in a multitude of scenarios in order to be of use to any actual simulation involving users of the Tygron Engine.

In this report we will go over aspects of the project, process and product.
First we will give an overview of the developed and implemented software product. Then a reflection is given on the product and process. This is done from a software engineering perspective. Thirdly, the developed functionalities are discussed. The fourth chapter contains a detailed explanation about our implementation of interaction design techniques. In the sixth section an evaluation of all the functional modules and the product in its entirety, including a failure analysis is given. Lastly an outlook on the project is given.

2 Overview

In this section we will give an overview of the developed and implemented software product. The developed product consists of a combination of software features. The two features are the Tygron Environment Connector and the GOAL Services Virtual Human. The architecture of the product consists of the GSVH connecting to Tygron Engine through our connector. The virtual human can retrieve information about the game and send actions to the game through the connector. The complete architecture of the product is discussed in our Architecture Design Report [3]. As mentioned before, the virtual human is built using the GOAL Agent Programming Language[1]. This language is a Prolog based artificial intellegence language in which agents derive their choice of action from beliefs, knowledge and goals.

2.1 Tygron Environment Connector

Over the course of the project we had to build on a pre-existing connector which connects the GOAL bot to the Tygron game. However, this severely lacked any useful features for implementing a GOAL driven virtual human. On top of the provided connector a lot of improvements have been made over the course of the project, of which the most important are that the bot gets more data and the implementation of extra actions our bot may use. All improvements over the original connector are put in a library package (in the form of a jar file). In this package contributions of all teams related to this context are put together. This package extends the connector with more percepts (data) about the game. The extension also contains custom actions, that allow our virtual human to be able to interact in a better way with the game.

2.2 GOAL Service Virtual Human

In total there are 5 groups that each develop their own virtual humans, so there are 5 different virtual humans. These take the role of mancipOur virtual human fulfills the services role in the scenario. This means that our virtual human can build convenience stores, terraces and sports centers in the TU Delft campus area. The game provides the virtual human with indicators related to these three categories our services need to cover. These indicators will provide us with a current value and a target value we would like to reach. The virtual human will make cognitive decisions based on these indicators and or experiences with other stakeholders present in the game, wether these other stakeholders are human or virtual humans. The virtual human is designed in such a way that it will behave like an actual human would in this game; by both reacting on other stakeholders and building believable buildings in the game.

3 Reflection

In this section we will reflect on the product and the process from a software engineering perspective. We will give information about how to improve and which lessons we have learned during this project.

3.1 Product

The final product we have made, is not the product we had in mind at the start of this project. We expected to have more interaction with the bot and to have a much better strategy. At the start of this project we expected that we had to implement a bot for the Tygron game and that the connector had all the information we needed. That we had to write a strategy for our bot so it was able to play in the Tygron game. Unfortunately we were wrong. We also had to implement the connector. We had to make sure all the information we needed for the bot, was implemented in the connector. So instead of using the percept, we had to write the percepts. This caused a big change in our plan. Because instead of focusing on a strategy, we needed to focus on implementing code to get percepts before even thinking about a strategy. So our final product is now a basic bot, who is able to do basic steps, like building and buying. But a very nice strategy or interaction with other bots, is not really there. The improvement for our bot is to have this nice strategy. We weren't able to have this, because we didn't have the information implemented in the connector. Now we have. So if we had another ten weeks for this project we should be able to build the strategy we had in mind. We should be able to think of a strategy and implement this using our code from the connector, because then we don't have to implement anything new in the connector, .

3.2 Process

Our process was quit organized. We used SCRUM to plan our sprints and almost every day we worked together. We discussed when we needed to approve pull requests and we helped each other out when there were issues with computers. Because sometimes, some computers had problems running Tygron. Then we would run the code on another computer. We had one team member, that was always late and sometimes didn't show up at all. He also did not do much for the product. We learned that communicating with the TA's can help a lot. Because we communicated each time he didn't show up and reported the exact hours everybody spend at something, instead of just filling in so everybody had enough time, we were able to show that he was a problem in the team. But he decided to stop and we became a team of 4 members. We kept communicating with each other when somebody was late or didn't show up, so we knew what was going on. Also we kept filling in the right hours even if this caused somebody to have less than 28 hours. IF you had less, then you had to make this extra hours the next week. An improvement of our process should be, to meet everyday and make sure the expected hours are spent. In this case we would be able to finish more tasks during a sprint.

4 Description

The services provider is responsible for a slew of services in the TU Delft campus area. Services include terraces, convenience stores and sports centers. These services need to be provided to all citizens of all the zones in the area. The design of our virtual human is based on the strategy descussed in 8.1. However, not every wanted feature has been implemented and thus in this section we will go over every implemented feature in the virtual human.

4.1 Decision making for buildings

By continiously consulting the indicators, the virtual human is able to decide, based on those indicators, what service building it should build. This is decided by which indicator is the lowest currently. When that decision is made, then the virtual human searches for a plot of land to build on. The build location is decided by looking at each zone and picking the zone which would allow us to provide the most citizens with our services. Next we look at the land we own ourself in that zone. If that yields a suitable place to build on, then the virtual human will build an appropriate size building on that piece of land. The size is computed based on the needed square meters of service building, that is needed in the chosen zone. If the virtual human does not already own a plot of land which suits the needs at the moment, then it will try to buy land from another stakeholder for an appropriate price. If a building is build, then the virtual human must request a building permit from the municipality. Only if that permit is granted, the building is actually build in the game and we will see it in the indicators.

4.2 Communication with other stakeholders

While playing our virtual human will have to reply to request by other stakeholders in the game. These might be received whenever a stakeholder wants to buy a piece of land from the services stakeholder. The virtual human will decide if we can spare the plot of land and if we are offered a good sum of money for it. It also takes into account that, if service buildings are on that specific plot of land, our indicators might drop. Another request we might receive would be when another stakeholder offers a piece of land to us. The virtual human will decide if we want that plot of land based on the need for land and the requested sum of money.

4.3 Indicators in the scenario

To gather information about the amount of floor size service buildings cover in the game, we designed and implemented excel-based indicators for the game. These indicators will score each service category seperately. Every zone gets a factor appropriate to the amount of citizens of that zone. Then the floor size is compared to the amount of housing units present in the zone and if that result matches a threshold, then that zone is statified with our services. The virtual human is designed to get convenience stores, terraces and sports centers to every citizen in every zone.

5 Interaction Design

5.1 Goal

The goal of our user study was to see how other players interact with our bot and how they experienced it. Because we need to replace a human by a bot, it should almost be like playing with a real human. So we needed to know what were the difference between playing with a bot or playing with a human.

5.2 Procedure

We tested six persons using our code. All six test persons were TI students which are also doing a context project, but they had another context. First we had to explain the tygron game to our test persons, because they needed to have an understanding of the game and it has a lot of options. So we needed to take time for explaining this.

Then we needed to explain them the tasks they had to do. They needed to play the game as the stakeholder municipality twice for 10 minutes. This could be twice against a bot, or twice against a human. Also it could be once against a human and once against a bot. When a human was playing it was just playing and not trying to simulate the bot. In this way we made sure we got the differences between bot an human, because our bot should look like a human not the other way around. They had to play the game and reach there goals in the games. This could be done by building, buying, selling and demolishing. By doing this they also had to interact with the other player.

After they played the game, we asked them how it went and if they thought they played with a bot or a human. Also they need to explain why they thought that.

These results were gathered together and written down. In this way we could find out if they could sense that they were playing against our bot.

5.3 Results

The complete results are given in appendix B. When we looked at the results, we saw that everybody was right about when they played against a human or a bot. There is only one person who doubted a little bit. But most of the times it was very clear when they played. The overall comment we got, was that the bot wasn't building on logical places, so We could adjust this to add more strategy in deciding where to build or buy. Another reaction we got was that when buying land and getting rejected, it tries to find another piece of land to buy instead of accepting to buy this land for a higher price. We intended to do this, but if the municipality keeps rejecting our request, then we have to buy it for a higher price. The last comment we got was that the bot is faster than a human.

5.4 Conclusion

Our conclusion is that we need more strategy in order to build at more logical places. Also we need an improvement for our strategy in buying land. We should be able to detect when it keeps getting rejected. We need to give a higher price when this is happening. It is not really possible to slow down the bot. The only thing we can do is to make sure it is going to the event module each time it has executed an action. In this way we get the most recently percepts and we are

faster in reaction to those changes. Also it should slow down building, because it has to go to the event module before it can build another building. So for the next time, we would extend our strategy. We won't focus on slowing down the bot, because this is not what we want. We don't want to build in a delay. We want the bot to think about what he needs to do instead of being as slow as a human.

6 Evaluation

In this section an evaluation of the functionalities performed using a well-justified method will be presented, as well as a failure analysis where the product does not perform as needed. This will be done for the functional modules, as well as for the product in its entirety. We will divide the functional modules into the building modules, and the modules for buying (land), selling (land) and demolishing (buildings).

6.1 buildConvienceStore, buildSportsCenter and buildTerrace

The first and foremost goal of our bot is to reach the indicators it is provided with, and to achieve this it needs to build buildings of a certain category in a certain area. For this we have 3 modules which work in more or less the same way: buildConvenienceStore for building convenience stores, buildSportsCenter for building sports centers and buildTerrace for building terraces. The way in which this is currently done is by first looking which has the lowest indicator at this moment, and dependent on that enter one of the three modules. Our current goal is to reach 80% of the indicator. The building is built on a random piece of land we own.

So as for the evaluation: currently the buildings are built, and in the right order of first building the building of which the indicator is lowest. This means the basic functionality is present. However it would be better if the location of where the building will be build is chosen at random. Instead there are a lot of factors which should influence this. For example you don't want the buildings too be to large or too small, you would not want terraces next to highways and you would not want to have two supermarkets next to each but rather spread out over different zones.

6.2 buyLand, sellLand and demolish

The other three functional modules we have are buyLand for buying land, sellLand for selling land and demolish for demolishing buildings.

If the bot can't build anything and it has not met its indicators yet it will want to demolish buildings in order to have the land to build buildings it needs for its indicators. In order to do this the bot looks at all the buildings it owns but which are not buildings that contribute to one of our indicators and then demolish them. Currently this is also done in a random order. It would have been better however to also implement a strategy for this. For example first demolish buildings in zones where the bot does not yet have buildings that contribute to its indicators.

If the bot has not met its indicators yet, does not have land without buildings on it and also does not have land with buildings on it that do not contribute to its indicators, it will try to buy land from other stakeholders. At this moment, only the basic functionality for buying land is implemented, which means land is being bought, but the land that is bought is choosen at random, there is however a maximum amount of money the bot pays for a certain area. This is however not a good way of doing this, therefor we are still working on implementing a strategy for deciding what land to buy.

Finally the bot has the sellLand module, which will only be entered once all the indicators are met. Since the bot start with very little land, the bot will need to buy more land instead of selling it. However it has achieved its indicators there is no more need for the rest of the land, therefor the bot will try to sell it for money.

6.3 Product as a whole

So in conclusion from the previously discussed modules: The bot can build the buildings it needs, will demolish the buildings it does not need if it needs the land to build the buildings it does need, will buy more land if it needs and sell its remaining land once the bot has reached its indicators. However it is necesary to add a strategy for deciding what buildings to build where and which land to buy, it would also be good to have a strategy for demolishing buildings but this is not strictly necessary. So we have a working bot which has all the basic functionality, however there is still room for a lot of improvement.

7 Outlook

Next time we work on this project, we will focus on implementing the strategy. The complete strategy we want to have is described in appendix A. All this is not yet implemented in our bot, because we didn't have enough time to implement the connector and the bot. So next time, we would start implementing this. We would like to have more interaction with the other stakeholders. Also we would like the connector to have more percepts based on our strategy. So we start with implementing the strategy and when we think we need a more specific percept, we would implement this is the connector. Instead of implementing things in the connector and then looking at the strategy. Because we have the basic implementation this is now possible.

References

[1] K. Hindriks. *GOAL 2.0*. URL: `http://ii.tudelft.nl/trac/goal` (visited on 06/16/2016).

[2] J. A. Todd and G. Lindsey. *Planning and Conducting Integrated Design (ID) Charrettes*. Apr. 9, 2013. URL: `https://www.wbdg.org/resources/charrettes.php` (visited on 04/05/2016).

[3] J. de Vries et al. *Virtual Humans for Serious Gaming: Architecture Design*. Delft, June 17, 2016.

8 Appendices

8.1 Appendix A: Strategy

In this section we describe what strategy we wanted to have for our bot. Also we will describe what strategy we really have.

8.1.1 What we wanted as a strategy

- behaviour concerning buildings:
  - A building should be able to change the indicators for services.
  - A building should be able to change indicators for other stakeholders.
    - This could be an advantage or a disadvantage for other stakeholders.
    - For example increase the green indicator or nuisance.
- behaviour concerning building:
  - A building could be built if this has the highest priority looking at the indicators.
  - A building could be built if this has positive results for all indicators.
  - A building should be built with a realistic shape.
  - A building should be built within the given size or area.
  - A building should be built based on other buildings and locations.
    - For example next to roads or close to other buildings you own.
- behaviour concerning demolishing:
  - A building could be demolished only when it has a minimum effect for that indicator.
  - A building could be demolished if it isn't any of the buildings services want to have, but services does own this building.
  - A building could be demolished if this is cheaper to use this land than buying new land.
- behaviour concerning selling:
  - A building should be sold when it has a minimum effect on that indicator and the money we get is enough to cover building the exact same building.
  - Land should be only be sold if we have enough land and we get enough money for this land.
    - There is enough land if all indicators have a 100% score or when this can be reached.
- behaviour concerning buying:
  - Land should be bought in realistic shapes.
  - Land should be bought from other stakeholders if there is no land to build on and the indicators don't have a 100% score yet.
  - Land should be bought if there is no land to build on and if the price for buying is better then demolishing or if demolishing is not an option.

  - Land should be bought if it is in a zone which is useful looking at the indicators.
  - Land should be bought when it doesn't have any buildings on it.
    * If this is not the case, we need to buy land that has building on it.
  - Land should be bought if other stakeholders are offering this land.
  - Land should be bought only when it is for an acceptable price.

- behaviour concerning interaction with other stakeholders:
  - The stakeholders should be able to stop buying and selling of buildings or land if this has negative effects on our indicators.
  - The stakeholder should be able to send messages to each other.
  - Municipality should be able to accept or reject building permits from services.
    * A new building permit should be reviewed by municipality when old building permits are rejected.
  - Services should be able to send a building permit to municipality when a building is build.
    * Services should be able to send another building permit is an old permit gets rejected by municipality.
  - Services should be able to offer land to other stakeholders.
  - Services should be able to negotiate and compete with other stakeholders about the price for selling and buying land.
  - Services should be able to negotiate and compete by giving secondary gifts.
    * For example increase the green indicator or give money to other stakeholders.
  - Services should be able to get more respect from other stakeholders by giving gifts, so we are able to do more when negotiating with these stakeholders.

8.1.2 What we have as a strategy

8.2 Appendix B: User Study Results

In this appendix, we describe the full results of our user study. For each person, we have written their reaction to our questions after each session. Also is given if they were playing against bots or humans.

8.2.1 person 1 (played twice against a human)

first time
"It is a great game!, I could demolish everything I wanted. I got some permits from other players for building items. It was weird, because the building was already there. When I rejected it, it took some time to let the building disappear. I think I played against a human, because a bot should be faster with reacting to my requests."

second time
"This time I played more seriously, so I build more parks instead of demolishing everything. I had to accept and reject the permits from another stakeholder. This time I am not sure if it is a human or a bot, because the placing of the buildings was quite nice and I heard this project wasn't going very well. So I expected not very nice behaviour of the bots. So I think this is a human."

8.2.2 person 2 (played twice against a human)

first time
"I was just waiting for the other stakeholder to do something. When I got a requests, then I would reject or accept randomly. I got multiple requests for buildings and buying land. It was all at logical places and the reaction time was normal. So I think it was a human."

second time
"This time I tried to buy, build and sell by myself. Also I accepted everything the other stakeholder asked. It was almost the same as the first time. So I think this should also be a human."

8.2.3 person 3 (played twice against a bot)

first time
"It went well, I could build some buildings and even was able to reach one of my indicator goals. I got a lot of requests from another stakeholder. I hadn't reacted to one and then the other was already there. It also had a lot of building at the same time. Because this went really fast, I think it was a bot."

second time
"Also this time it went well. I also tried sold some land to another stakeholder for a very high price. But the stakeholder didn't accept this. The stakeholder did again build very fast and a lot. I also saw that not every building had a logical place. I don't know for sure if I played against a bot or a human, because I would have expected that if the stakeholder was a bot that he would accept the land I wanted to sell. A human wouldn't built at those places, thus I think I was a bot."

8.2.4 person 4 (played twice against a bot)

first time
"It was a easy game. It looked like Sims City. I like the game. I found out that the municipality wants to increase livability. Also I got requests for buying land from another stakeholder. I declined it, because I wanted more money, so I tried to sell the same land for a higher price. But the stakeholder rejected it and kept buying different plots of lands for the same low price. So I kept rejecting. Because it never accepted my sell requests and kept going on trying to buy other plots of lands, I think this was a bot."

second time
"This time I reached all indicators, so I won. Because I didn't need any land, I accepted the buy requests I got. Then the other stakeholder started building nice terraces and convenience stores, which was also good for my indicators. So I only had to accept the price the stakeholder offered for my land. The stakeholder didn't have much variation in what he was doing, so I think it was a bot."

8.2.5 person 5 (played first against a bot and then against a human)

first time
"It didn't go as expected, because the game was very slow. It didn't react in the way it should. Also it is not possible to change your selected part for building. I saw that another stakeholder was building very fast. It had a lot of buildings in a small amount of time. That is why I think that I played against a bot. A human would never be able to build that fast."

second time
"The game still didn't work as expected. It was not clear which zone was the zone you needed for your indicator. Also it is possible to build a building inside another building, so it is not possible to reach this building, this is weird. The stakeholder was still building buildings and I got several permits. This time the building were build at more logical places and it was slower then the first time. So this time I think I played against a human."

8.2.6 person 6 (played first against a bot and then against a human)

first time
"It went okay, I had to get used to the Tygron game, but after that I could play the game very well. I got a request to buy land and I accepted it. Everything went well when interacting with the other stakeholder. When I tried to buy something, it first rejected it, but when I offered more money it accepted. It was remarkable that the bot always had building of the same size and always next to a road. It looked like the stakeholder was thinking about what he did, but it had some weird actions like building on strange locations. So I think this was a bot"

second time
"Everything went well and the reaction was fast when I send a request. I changed some stuff in my game and the stakeholder rejected or accepted alternately. It built at logic locations. There weren't very remarkable thinks going on. But the things that happen were less predictable, so I think this time is was a human."