Preservation of Mediterranean Intangible Cultural Heritage through virtual gaming and Informatics: the case of Sardinian Mùrra.

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ABSTRACT [1]

Human-Machine interaction has always presented fascinating challenges for researchers. In the context of humanities, history and social sciences, games have played an important role in human relations. As UNESCO points out, the dazzling variety of forms taken by traditional games is part of the social practices, rituals and festive events we inherit from our ancestors. In the spirit of safeguarding this cultural richness, digitization of games like the traditional Mediterranean Mùrra (or Morra) could contribute to preserving the rich European cultural heritage. Though there are many regional variants of the game, here we will focus on the Sardinian version. This research project proposal could be developed by computer scientists interested in human-machine interaction as well as by humanists and psychologists interested in human reactions to interfacing with an intelligent machine and negotiating wins and losses with a form of AI. This work could be further developed by scholars in the fields of psychology, sociology, history and cultural anthropology.

Keywords: Digital Humanities, Gaming, Intangible Cultural Heritage, Sardinian Mùrra.

1. INTRODUCTION

The Mùrra is a simple game, played between two or four players in pairs. The objective is accurately guessing the sum of numbers played by both sides in each play. In spite of its simple rules, the game's complexity lies in the statistical prediction players must make of their opponent's hand, whilst quickly mentally adding the numerical value of their own play and then verbally calling out the predicted sum. If the players were neutral machines generating random numbers and calls, stochastic independency would ensure an endlessly balanced game. However, humans are subject to the influence of many factors such as physical environment, emotional state, and degree of experience which ensure the game's outcome is variable. For instance, if one player is skilled at identifying a pattern in the opponent's throws, it may become easy to win the exchanges based on these predictions. Likewise, being emotionally influenced by the thrill of a win could cloud judgment on subsequent plays. It would be interesting to transpose the game into a virtual environment by creating a system instructed on the algorithm of the game, using Artificial Intelligence and motion capture techniques utilizing audio capture as well as visual capture. Gesture sensors with or without haptic devices would reproduce a real match environment. Considering that for a beginner the easiest way to practice is simply playing in front of a mirror against himself, the same training technique can be transposed into an IT system which could evolve itself little by little thanks to adaptive, self-training machine deep learning techniques. Using VR or AR through headsets with visors, goggles or simply with internal or external projections such as monitors or any surface, this device could be an operational machine installed in museums as a permanent or itinerant interactive exhibit to showcase a part of the Mediterranean Intangible Cultural Heritage. Such a device could also be used to engage in remote competition between people or the avatars they impersonate through the available platform interfaces. In addition to remote Human vs. Human play, users could enjoy Human vs. Machine games locally or remotely. The beauty of Mùrra also lies in its musicality: keeping the tempo helps to acquire a musical ear and a sense of rhythm. It also helps to keep and refresh mathematical skills thanks to the quick reaction time needed in processing numbers. Furthermore, the game requires developing self-control and attention even in the face of conflicting stimuli (the hand gestures one number, the vocal call is a different number). The

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game has simple rules; it is affordable and can be easily translated across languages and cultures. In this sense, by exploiting the power of informatics and new technologies, gaming can bring together different cultures and diverse people for an intercultural dialogue. The IT apparatus needed to replicate the game, however, must respond to the complex task of mastering a real-time translation of the opponents' vocal calls and physical hand plays based on the finger positions displayed each time on the opponent's hand.

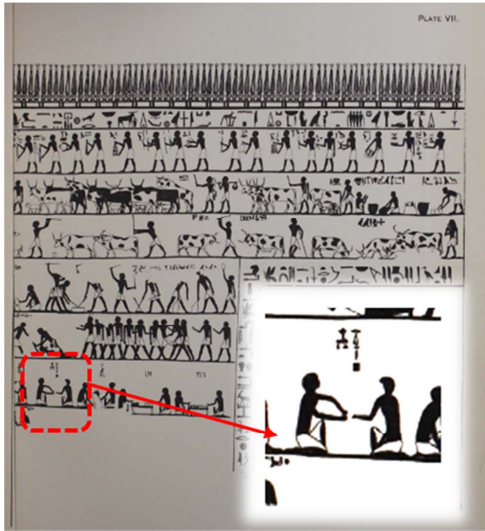## 2. PROBABLE ORIGINS AND HISTORY OF THE GAME

Figure 1 Egyptians playing a sort of Mùrra Game

The origin of Mùrra is quite debated because it is a very ancient game. Not being a historian, after some research I came across some images depicting Egyptian people playing the game. Since they are the probable first appearance of the game, these Egyptian wall pictures and a later Latin statement are most significant.

To summarize, I inquired with the Museo Egizio in Turin [1] and the Grand Egyptian Museum in El Cairo [2] for some authoritative references on those pictures. A kind curator of the Museo Egizio in Turin[2] provided some references about those unknown pictures I had found in the literature. The pictures come from tomb n. 15 of Baqt in Beni Hassan, in particular from the central chamber, south wall [3].

Regarding the Latin statement M. T. Ciceronis wrote «...:cum enim fidem alicujus bonitatemque laudant, dignum esse dicunt, "quicum in tenebris mices." ». which loosely translates to: "anyone, whose faith and goodness is praised so much, with whom you can play morra in the dark" [4]. For the ancient Romans, *micare digitis* meant

"to vibrate with the fingers".

All the history in between then and now, though rich in events and evolutions, is poorly documented or fragmented. It is nonetheless clear that the daily practice of this game spread across the Mediterranean and beyond and has been adapted in many regional variants (think about the simpler "Odds and Evens" game of chance).

3. PERSONAL EXPERIENCE OF THE GAME

The idea of this AI implementation of the game has roots in my first approach to Mùrra. Ever since I was young, I was always fascinated by this game. The first contexts in which I played were between friends, during dinners, usually in front of a fireplace, while drinking pints of a good beer or delicious Cannonau red wine. As a beginner, I tended to be shy and insecure in the first matches, so the more experienced seniors gave me practical advice on how to practice: face off against myself in front of a mirror. The first times I played, I tended to call the same number I was throwing- this is a common mistake made by beginners: e.g., if you throw the number two with your hand, you are mentally conditioned to vocally call out that same number you are throwing, instead of calling a different one. As the game consist in guessing the sum of the two opponents' throws, we must call a higher number than the one we throw to have a chance to win. Voice stress, vigorous arm movements, firm hand throws in a rhythmic cadence are the characteristics of an experienced and confident player. This lends itself to creating a system to practice the game in a virtual yet realistic, environment.

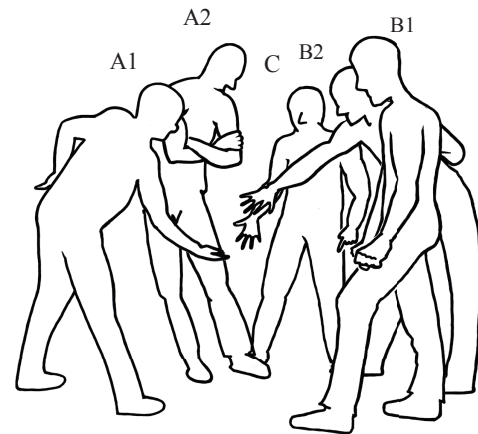## 4. DESCRIPTION OF THE GAME AND ALGORITHM

Figure 2 Four players with arbiter scenario

In reality, Mùrra always takes place between two opposing players A and B. This is most common in private

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[2] I would like to thank Mrs. Federica Facchetti, curator at the Museo Egizio in Turin as part of Fondazione Museo delle Antichità Egizie di Torino for her kind assistance. Not being an

expert on the subject I was investigating, she also provided the following resources to delve deeper into the topic [5] [6] [7] [8].

home settings. The most common scenario, however, is between four opposing players grouped in pairs, either privately, in public or during tournaments: A1 and A2 (members of the pair, or team, A) against B1 and B2 (members of the pair, or team, B). The game can be supervised by a third-party C who acts as an arbitrator in the event of a dispute and keeps the score, counting the points obtained by the playing teams or single players. In both cases (two or four players), opponents always play one on one in turn. Although it is possible to play in two or in four without the presence of the referee, the respective players, or teams, must keep in mind their own score and that one their playmate (if playing in teams). The high risk of losing count is the reason there is a tendency to prefer the presence of an arbitrator who deals with this task. The game consists in throwing a number by gesturing the fingers of one hand whilst simultaneously calling out another number, aloud and clearly. The player calls out the number he believes will be the sum of his own throw and the opponent's; this guess is of course made *a priori*. The two numbers thrown by each player added each other give the final sum both are trying to correctly guess (not just approximate or come closest to). The player who guesses the right value, wins, keeps the turn or, as it is also said "holds the hand".
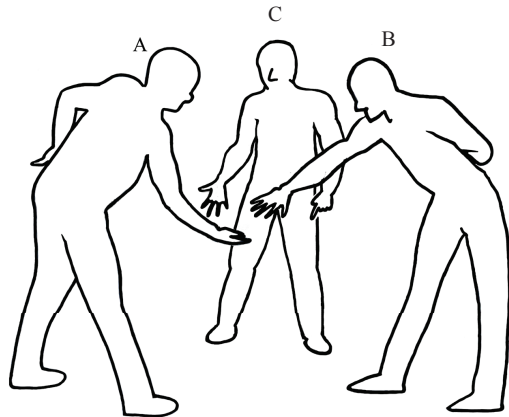

Figure 3 Two players with arbiter scenario

If we imagine a two-player scenario, starting arbitrarily with A vs B (but it is obviously the same if B starts versus A), one of the possible resulting algorithms could be represented by a flow chart, as follows:
PAS = Player A Score; PBS = Player B Score; MFS = Match Final Score; M = Match Type; N = Normal; B = Bella; H = Hand. Every call essentially represents a bet. "A vs. B" could be represented by the following pattern in which the players are indicated by the letters before the colons ":", the sharp "#" is the number thrown by the player specified in the respective subscript, "SUM" is the sum to be guessed, declared in a clear manner aloud *a priori* by the player indicated in the respective subscripts:
A vs B $\Rightarrow$ A : $\#_A$, SUM_A & B : $\#_B$, SUM_B
If $\#_A + \#_B = SUM_A$ && $\#_A + \#_B \neq SUM_B$, A wins and A's score is increased by one point.

If $\#_A + \#_B \neq SUM_A$ && $\#_A + \#_B = SUM_B$, B wins and B's score is increased by one point.
If $\#_A + \#_B = SUM_A$ && $\#_A + \#_B = SUM_B$, the result is the same and the bet must be repeated.
If $\#_A + \#_B \neq SUM_A$ && $\#_A + \#_B \neq SUM_B$, the result is the same and the bet must be repeated.
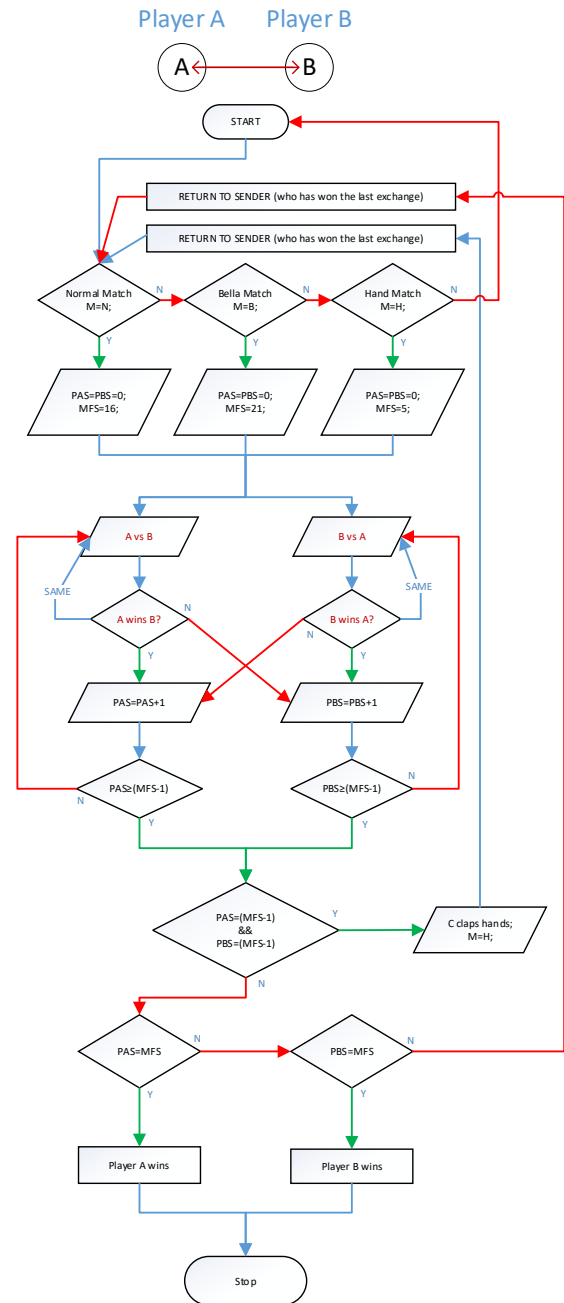
SARDINIAN MURRA GAME
1 vs 1 ALGORITHM

Figure 4 Two players (with arbiter/counter) algorithm

The same notation can be extended by analogy to the game between four players and to any of the eight possible

combinations in the exchanges between all players (A1 vs B1, A1 vs B2, A2 vs B1, A2 vs B2, B1 vs A1, B1 vs A2, B2 vs A1, B2 vs A2). The related steps can be extended to the algorithm between pairs by simply changing the expressions' subscripts associated to each player.

The matches can be of three different kinds: Normal match (N), Bella match (B), Hand match (H). From the beginning, the players and the arbiter agree about the number of winning matches needed to win the game: two out of three, or three out of five.

After winning a game, another team can challenge the winning team. If this second team wins the game, both teams can play the Bella, which consists in longer matches, with final scores of 21 each. If both teams reach the score of 15-15 in normal matches, or 20-20 in the Bella match, the arbiter claps his hands, to indicate that a match *alla mano* ("*at the hand*") has started: the scores are reset to zero and the match continues until a team reaches 5 points first, because the advantage must be at least of two points. If the teams reach the score of 4-4 at the same time, the arbiter claps his hands again, resetting both scores to zero and restarting a match *alla mano*. By induction, we can rewrite this algorithm with a little extra complexity, adapting it for a match between four players. In fact, we could indifferently use two or four players in a digital and virtual environment, just as we play in real life.

The place where I learned the game, also my hometown, is Macomèr, a little town in the Nùoro Province, in Sardinia, Italy. The numbers' pronunciation in the Macomer variant are: ùnu (1) never used and useless for the purpose of the game; dùos (2); très(e) (3); bàttor(o) (4); chìmbe (5); sès(e) (6); sètte (7); òtto (8); nòe (9); dèghe (10) which, in this game, is called out with the word Mùrra, i.e., the game name itself. Numbers' variants and most common replies, usually dotted notes or triplets, such as: dùru-dù, dùdduru (2), trèmmedi (3), barànta, baràttu (4), chìmbe-chì (5), sèi-sò, sèighi, sessànta (6), settànta (7); òtto, ottànta (8); nòve-nò (9); mùrra-bella (10). In musical notation, the tempo of execution is cadenced and musical; in my opinion, the most suitable time rate is between 65 and 90 bpm, even if during the game it could increase because of the excitement of the contenders, thus tending to be more disordered and disharmonic. The most common time division used is triplets and dotted notes, with a stress on the second syllabic division for each point answer back.

There are many other ways to reply- nice, funny, or sometimes covertly offensive or sarcastic; this depends on the context in which you play and the creativity of the players, who create an exciting and colorful environment. The game can be considered a gambling game, and for this reason in some places the local laws forbid it. Even though the calls or bets should be random or pseudo-random, it is possible to predict the opponent's bets by studying each the opponents' hand and calculating the presentation frequency of a symbol (number) compared to others. It is a pattern of repeated tests of Bernoulli with a 1/5 probability of success[3]: I have to guess which of the five symbols the opponent will throw so as to call out the predicted resulting sum of the throws. However, the game retains a dose of randomness: thanks to the players' ability, it is possible to vary the individual throws, randomly. Leaving aside the techniques of speed, rhythm and skilful gestural artifices used to change the bets during each exchange, a correct performance of the contest makes the game exciting and intriguing. Earning points can be complicated and exhausting, especially when the counterparties are balanced. Exchanges can last an undetermined amount of time and the ability to read statistically the opposing hand allows you to obtain points, uncovering the opponent's vulnerabilities while understanding the higher frequency of a number bet with respect to others. Control over the game is maintained by the referee, who also ensures a correct execution of the game and with clear and intelligible hand gestures. The thrown symbols (numbers) must be clear and never ambiguous: the position of the fingers must end statically at the time of the vocal call (bet). It is prohibited to make any change in the position of the fingers or to try to otherwise camouflage the thrown number in favor of what has been vocally declared. This artifice, called *scalare* or *iscalare* in Sardinian, allows, if performed with speed and shrewdness, to cheat on the result. This is why players are not allowed for any reason to change their fingers' position or put their hand perpendicularly to the field, but always flat. The position of the said flat hand is always parallel to the ground, hand upright or upside down; the edgeways position is perpendicular to the ground and therefore difficult, if not impossible, to read for players looking at the throws from the top perpendicularly to the ground. Even in this case, if a dispute should arise, the impartiality of the arbitrator, who sees from a different angle, oversees the regularity of the throws and can declare them null if deemed irregular. Edgeways bets should be always avoided.

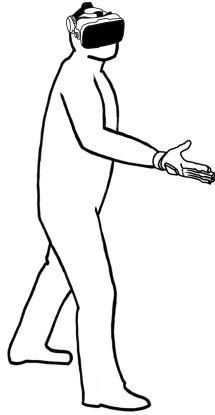## 5. KINESICS, HAND MOTION CAPTURE AND ENVIRONMENT ACQUISITION

Figure 5 Player with headset and haptic glove

To translate this scenario into a digital environment, we can divide the motion capture in two main phases: one, general body and arm motion capture to animate an avatar into Virtual Environments (VEs) and two, fine motor skills and specific hand and finger digit motion capture. The latter can be obtained via sensory or visual capture, or a combination of both. Thanks to new generation sensitive haptic gloves [9] or proven image recognition systems for Human-Computer Interaction (HCI) in VEs [10] [11], we can acquire all the finger positions and each combination used to represent a single number, mapping all of them to the respective numeric value, from 1 to 5. Using the second technique with cameras requires a few more precautions to recognize symbols in any position (edgeways or upside-down positions); the use of sensitive gloves solves this problem, as the position of the fingers can be detected and coded irrespective of the hand's angle. All the numbers, their variants and corresponding vocal sounds will be acquired and recorded in a dictionary using a vocal recognition engine. For each number and its synonyms, the sounds and phonemes will be associated to their respective numeric value (and this can be done for each international language, creating a comparison table of different language expressions and phonemes, of the same number). The fingers' position will be the addenda (four players scenario: $\#_{A1}$; $\#_{B1}$; $\#_{A2}$; $\#_{B2}$) of the operation, instead, the number called loudly and clearly, the expected result (four players scenario: SUM_{A1}; SUM_{A2}; SUM_{B1}; SUM_{B2}). Then an ALU will take charge of all the operations needed for following the game's rules.

6. AI AND VIRTUAL PLATFORM

The goal of this interactive system is to play and practice the game alone, against a machine or challenging other people through the platform, just as it happens in real tournaments. In the first context, the game could be played at home or in other places depending on the available devices and the different ways used to display the

opponents. Such systems could include, but not be limited to, large displays with environmental microphone and sound systems with cameras or haptic gloves; wall projectors with environmental microphones and sound systems with cameras or haptic gloves; totems with environmental microphones and sound systems with cameras or haptic gloves; VR goggles, earphones and haptic gloves, VR headsets and haptic gloves; 3D system projectors or 3d beams. Once we have collected all the body motions and finger combinations and trained the system, we can start to play through gradual levels of complexity. It is interesting to explore the challenge between the human player and an AI avatar or against two different AI avatars.
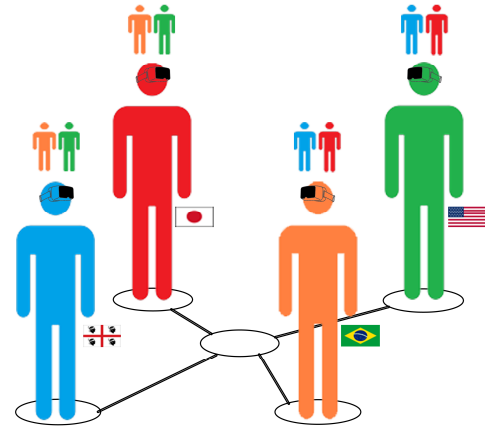

Figure 6 Distributed hybrid multiplayer scenario

Using a self-training engine, the AI itself will be able to "read" the human opponent's hands, predicting, on a statistical basis, which will be the next probable number thrown. During a training phase, the system would start to learn any repetitions in the symbols thrown by the human player, collecting a statistical analysis on the recurrences, generating its own numbers, and declaring the guessed sum whilst keeping in mind this analysis. Once trained, the machine will become increasingly difficult to beat, tending to be unbeatable.

Tournaments could be held in a virtual environment connected by hi-speed networks with minimal latency time response. This would make it possible to play a game between physically distant players who impersonate virtual avatars whose movements are either determined by the real remote opponents or autonomously by the IT system. A player could also simply challenge an AI to a one-on-one challenge, Human vs Machine, or one human wearing VR goggles headset, versus two AI players impersonated by an animated avatar in the virtual environment.

7. CONCLUSIONS

The excitement and involvement generated by facing a real opponent is never replaceable by virtual play: feelings and variables during a real game, including facial and

verbal expressions, sounds, smells and the surrounding environment, are unique. Nevertheless, the purposes of this system and resulting applications, with its progressive enhancements, are manifold: to preserve this game belonging to the intangible Mediterranean cultural heritage and to Sardinia by spreading and teaching it; to enable people to practice in a virtual environment without being bound to a specific place or platform device, being ready for real matches, anywhere worldwide[4] through custom modifications of the algorithm according to regional variants. Mùrra stimulates reasoning and mathematical skills, helps to refine observation techniques and probabilistic forecasting skills, and trains the ear to musicality and rhythm. Furthermore, it requires sustaining attention even whilst facing disjointed stimuli and cultivating self-control both emotionally and in terms of physical gesture control. Playing a gambling game against an Artificial Intelligence that is able to progressively learn during the game itself the techniques needed to win against the human players can have fascinating applications. The technology could also be placed in a permanent or itinerant museum exhibit to testify an anthropological practice and a social game that reaches the whole Mediterranean and beyond. Studying the interactions between human players versus an Intelligent System will help us discover more aspects of the cognitive processes that are already being studied [12]. It could be interesting to study linked neurological and physiological effects of practicing this game by interfacing Holter monitors to study the body's reactions and activity during both a real game and a virtual one, then comparing the results. There have been several attempts to reproduce the challenge against robot prototypes (in 2010 Prof. A. Zizi, and his students at the high school IT Giua in Cagliari created "Gavin 1.0", the first Mùrra robot player, revisited in a newer version "Gavin 2.0" in 2014) [13]), with apps usable on smart devices [14], and patents. The virtualization proposed here does not bind players to a particular humanoid, robot or platform; it would model reality and be transposed into any virtual environment. The fact the human player could not know if his opponent is a human-controlled avatar or an AI adversary creates repeated Turing tests, which could have interesting research ramifications. Motion and gestures captured with haptic devices or with visual motion capture techniques can be nimbly transposed into different physical media and several devices, thus helping to preserve this intangible heritage even in the digital world.

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[4]A curious anecdote, which led me to propose a worldwide extension of the game, in addition to the attempts promoted by other scholars and enthusiasts, is that I have been able to teach this game to my American friend Nick. Nicholas J. Ferrara from Gettysburg (Pa), moved to University of Texas at Austin as assistant vice president of the University Development Office. He prematurely passed away in 2010. Every time he came back

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to Sardinia to meet us, we always used to play this game. Once learned, he was able to play it proficiently with a cool American pronunciation of our Sardinian numbers, and returning to U.S., he loved to play it with some of his friends there. "This game has definitely no borders", I thought...

International Conference on Spatial Cognition – Rome.

[13] URL: http://www.giua.edu.it/gavin-10.html (visited July 2020).

[14] Dr. Davide Onida et al. developed (2018) an app "Sa Murra" for smart devices available both for Apple and for Android:
URL:https://apps.apple.com/it/app/samurra/id1276164851 (visited July 2020);
URL:https://play.google.com/store/apps/details?id=com.samurra&hl=it (visited July 2020).