DIA: A Human AI Hybrid Conversational Assistant for Developing Contexts

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ABSTRACT

Social media messaging applications(i.e. WhatsApp, Facebook) have reached 2.3 billion users in 2019, with the majority of users emerging from developing countries. The high usage among emergent users opens the possibility of designing text-based interventions for social change but such interventions rely on experts (i.e. doctors, educators, and moderators) knowledge which is scarce in developing contexts. Expert knowledge can be scaled up using chatbots but more research is needed to support emergent users who need context-specific support such as local language interventions or may not have regular internet connectivity. Therefore to support the design of chatbot based interventions in low resource contexts, we built *DIA* a chatbot architecture for low resource contexts to scale expert knowledge and support localization. *DIA* is a human-chatbot (humbot) hybrid system that organically learns topic-specific knowledge and local language from user interactions. We built a preliminary version of *DIA* on WhatsApp and deployed it to mentor 38 teachers in a rural context of Côte d'Ivoire. Through our preliminary deployment, we show that *DIA* can help (1) build a data-set of a topic and language-specific dialogues (2) understand users' online smartphone usage through chat logs and (3) collect survey data for through conversational interaction.

CCS CONCEPTS

• **Applied computing** → *Education*; **Computers in other domains**; • **Human-centered computing** → *Ubiquitous and mobile computing systems and tools.*

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1 INTRODUCTION

In 2019, social media messaging applications i.e. WhatsApp and Facebook Messenger collectively reached 2.3 billion users, with the majority of active users from developing countries [38]. The high usage from developing countries opens up the design space for text-based interventions on social media messaging [3, 14, 27]. However, the primary challenge in developing countries is the severe lack of experts(e.g. it is estimated that there is 1 doctor for 5000 people in parts of sub-Saharan Africa [39]) who act as the backbone of impactful interventions. Another challenge is that a lot of users in developing contexts are *emergent users* [10] who are newly getting access to mobile devices and are living in rural areas which leads them to have different usage behaviors than traditional users [24]. Therefore more research is needed to understand design opportunities for text-based interventions on social media for emergent users in developing contexts.

Prior research has scaled expert knowledge for text messaging by using conversational agents or chatbots. However, the majority of this work has been designed for traditional users in western settings to interact with the chatbot in English[36]. Using these chatbots in developing contexts is challenging because a lot of emergent users may not prefer English and hence might use a colloquial variant(Hinglish in India) [25] or prefer a local language (Kinyarwanda in Rwanda)[33]. Such languages or local variants do not have readily available datasets or translation support hence make it harder to design chatbots for the users. Another challenge is that unlike traditional users, emergent users are learning to use social media elements(such as multimedia) and hence might need additional support to help them engage with the system [24]. Therefore, there is a need for a prototyping tool for facilitating the design of chat-based interventions for emergent users in low resource contexts.

Figure 1: A participant interacting with *DIA* . We deployed *DIA* as a WhatsApp Assistant in rural Côte d'Ivoire for 4 weeks to mentor 38 teachers.

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This paper describes *DIA* : a human-chatbot(humbot) hybrid system that is designed for scaling expert knowledge in low resource context. Our system can be used to learn topic-specific knowledge and local language from user interactions. We demonstrate the example of our system's utility in the context of teacher training in a developing context. In developing countries, teachers are trained through visits by ministry officials or teacher trainers [15, 18]. However, trainers infrequently visit teachers (averaging up to 2 days in a year in Côte d'Ivoire [23]) due to infrastructural issues impeding travel and large number schools assigned per teacher trainers [6, 20]. We ran a field study to understand the feasibility of *DIA* to scale limited teacher trainer support to more teachers with technology. We deployed *DIA* to mentor 38 teachers in rural contexts of Côte d'Ivoire using WhatsApp. Our research team played to the role of experts and answered questions which the chatbot was unable to answer. Through our preliminary deployment, we show that the system can help (1) build a data-set of topic and language-specific dialogues to understand (2) understand users' online smartphone usage through chatbot logs and (3) collect survey data for through conversational interaction. Through our deployment, we were able to explore the design space of scaling teacher training in low resource contexts. For future work, we plan to use mentors or peers to solicit answers and automate itself over time.

2 RELATED WORK

Early work in text messaging focused on sending one-way messaging [9, 33] to provide information to the user but users found it challenging to interact without feedback. Therefore, projects have moved towards providing two-way feedback for health [31], education [49], and agriculture [46] with expert support. Researchers have extended expert support to create human-machine hybrids in finance[8] and healthcare [30] by automating a part of the interaction. However, text messaging-based applications are limited by the cost of messaging reducing sustainability and lack of availability of experts reducing scalability [30, 31, 49]. To improve sustainability, research has shifted to use text messaging on social media in education [3], healthcare [14], activism [35], and election monitoring [27]. However, this work on text messaging through social media platforms is dependent on the availability of experts which is a scarce resource in developing contexts.

Chatbots or conversational agents have the power to scale up expert knowledge through artificial intelligence [17]. The first chatbot Eliza was developed in 1966 to emulate a therapist using simple rules of language understanding [47]. Today chatbots are being used by 1.4 billion users on various platforms on home assistants and social media platforms like Skype, Whatsapp, and Facebook [13, 36]. On Facebook Messenger alone, it is estimated that there are 300,000 chatbots [36]. Chatbots have been classified based on usage [13], customer support agents for product search (Alibaba), personal assistant chatbots(Amazon Alexa, Google Home) for content curation(CNN News) and coaching(WoeBot [28]). Prior work has tried to scale chatbot capabilities by using human-machine hybrids [17] or humbots which combine expert knowledge with innovative AI techniques[19]. Additional research has expanded chatbots through Crowd-AI hybrid architecture to automate conversations over time [19] by utilizing crowd workers to support AI when it fails to retrieve an appropriate response. Additionally, prior work has used chatbots to mediate experts critique learners in short intervals of time on social media [42]. However, a majority of this work is focused on western settings in the English language [36] which may not transfer to developing contexts due to lack of language datasets or translation support leading to a further need to rely on experts. In developing contexts, prior work has focused on a voice-based chatbot for low literate users [21] and explore design opportunities for novice urban users interacting with Facebook Messenger chatbots [22]. However, more research is needed to explore opportunities to design chatbot based systems to support local language interaction using text messaging in low resource settings.

3 DIA

Therefore, we developed *DIA* a human-chatbot (humbot) hybrid system to design chat-based interventions for the developing world. Our tool is a human chatbot hybrid designed to scale expert knowledge. We designed it for social media to improve sustainability and to allow local language interaction to support emergent users. Users interact with the system using social media messaging platforms such as Facebook Messenger or WhatsApp. An NLU(Natural Language Understanding) engine parses user response and returns a response from the appropriate module of (1) Automated intents, (2) Knowledgebase or (3) request help from an expert.

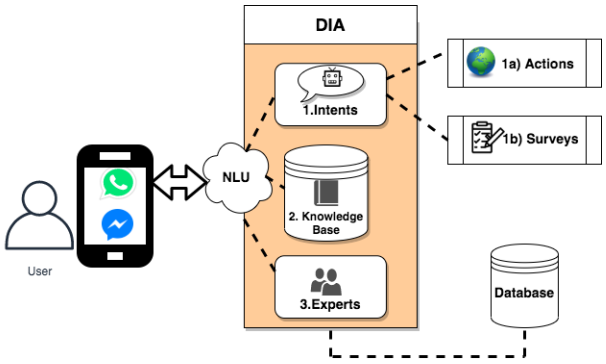

Figure 2: Shows the architecture of *DIA* consisting of (1) Intents of automated interactions (2) Knowledge base of curated questions (3) Experts who interact when 1 and 2 fail to provide an appropriate response.

(1) **Intents** consists of simple pre-built conversations for engaging in small talk (such as greetings, introductions, jokes). These pre-built intents are triggered upon a keyword or a specific command for e.g. *Tell me a joke.* Another set of intents is dynamic and ideal of task-specific conversations. Task-specific conversations are classified into two modules of actions and surveys.

- (1a) *actions* which are scripts tasked with local computation(e.g. dictionary, calculator) or fetching information from the internet (e.g. Wikipedia). This information is parsed and returned to the user with an excerpt and a link if applicable. e.g. (*What are the citations of Kant?*)

- (1b) *surveys* that can be used to gather qualitative or quantitative data from the user by asking sequential questions. The survey module can also be used to send information with text or multimedia (videos, audios, or pictures) to create a human conversation. e.g. (*In which school do you teach?*)

(2) **Knowledge-base** is the database of content-specific questions that form the core curriculum of the chatbot interactions, they are curated by seeding the chatbot with data initially or by dynamically building from the database by interactions with experts. e.g. (*How to Implement TaRL?*)

(3) **Experts** form the final source of content when the chatbot fails to assign appropriate automated response. Our system gives the user a choice to request help from an expert, following the HCAI principles [4] e.g. (*I am sorry, I don't know the answer to this, would you like me to ask my superior and get back?*)

All the data is stored in the database to add expert interactions to the knowledge base and improve the agents' linguistic capabilities. Therefore over time, expert knowledge can be populated to the database leading to more automated and natural interaction. The interactions described so far have been user-initiated.

DIA can initiate interactions by sending personalized bulk messages [8, 32] to the users which can be used to trigger conversations or conduct surveys. The survey questions are monitored by the administrators who can add or remove questions from the dashboard. The qualitative and quantitative data collected from user surveys can be used to collect insights about the community. Lastly, the system can also detect the *read status* of the user to understand internet usage and different forms of user engagement.

4 CONTEXT

This study is part of an ongoing research program on supporting literacy in cocoa farming communities in rural Côte d'Ivoire. This project aims to improve child education through poverty reduction and improved educational quality. Educational outcomes [15, 18] can be improved by teacher training but implementing such interventions in rural areas is challenging due to infrastructural issues and *lack of available teacher trainers* [6, 20]. Recently in Côte d'Ivoire, a new teacher training method i.e. Teaching at the Right Level(TaRL) has been implemented by the TaRL Africa team [2] in collaboration with the Ivorian Ministry. Prior research has shown the success of this teacher training method in Indian and other African contexts [1, 5]. This project is a collaboration with the TaRL Africa team to learn the feasibility of *DIA* to mentor more teachers in the teacher training method(TaRL) with technology. We conducted a pilot study in Méagui a rural area of Côte d'Ivoire during the TaRL implementation session of January 2020. The research team introduced the teachers to the WhatsApp assistant during the TaRL training classes and we instructed teachers to chat with the assistant to seek support with TaRL. We also told the teachers that the chatbot can answer questions outside TaRL but our system will prioritize answering questions related to TaRL and teaching. Teachers were not given any incentive to interact with the chatbot. We conducted the study for 4 weeks to answer the following research question.

RQ: What is the feasibility of a chatbot(*DIA*) to mentor teachers in rural contexts in low resource contexts like Côte d'Ivoire?.

5 FIELD DEPLOYMENT

To conduct a preliminary evaluation of our system, we received IRB approval from the University of Delaware (protocol *1478038-1*) and we deployed *DIA* on WhatsApp to mentor 38 teachers in the rural context of Côte d'Ivoire for 4 weeks. The system was developed using Flask [12] (a Python framework) and Twilio [43] to support interactions on WhatsApp. We used DialogFlow [11] for basic intents(i.e. for small talk, jokes) and writing custom functions in Flask for complex intents (i.e. Wikipedia, conjugations, calculator). We built our knowledge base using the TaRL manuals and we used cosine similarity to match the appropriate response. Lastly, we built a dashboard where researchers played the role of experts and answered questions referring to the manual on the teaching method [41] and Google search for complex questions.

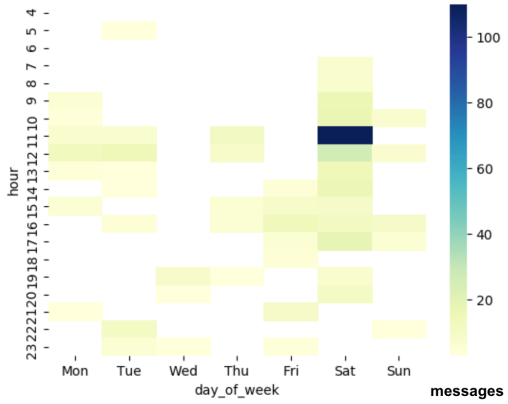

Figure 3: This figure shows the cumulative usage of *DIA* by the teachers every hour. We see that teachers use the system on Saturday afternoons or after school hours.

We deployed the bot for 4 weeks and learned about the feasibility of using *DIA* for supporting teachers in rural Côte d'Ivoire . Teachers were encouraged to use the system whenever they needed support with teaching and there was no incentive provided for using the chatbot. Teachers interacted on a total of 2132 messages (930 from users), more than 98% of the conversation used accurate French words (indicating teachers usage of autocorrect). Although we intended the bot to be teaching method focused, we received a total of 97 questions related to education, football, current affairs, health, and finance.

The Fig.3 above shows the usage of the chatbot for 4 weeks. Teachers communicated most with the chatbots on Saturday afternoons, during their breaks (12:30-2), or after class. We inferred that teachers do not have access to the internet daily through message delivery logs. We also conducted chat-based surveys about the teaching method and sent motivational messages to the teachers. We observed that all 35 teachers answered the initial entry survey of 8 questions, 32(91%) teachers answered 12 follow up questions in the first week and 12(34%) answered all questions by the end of 3 weeks with approximately one reminder a week.

6 DISCUSSION

Our current implementation had some workarounds to function smoothly on WhatsApp. Firstly, WhatsApp API [48] restricts free-form interaction with the user in a 24-hour session, beyond which only template greetings (e.g. *Your code is XYZ*) are allowed to be sent to the user. Since the pre-approved templates in Twilio [43] were in English, we added a French question after the English template which may have led to low survey feedback from the teachers. Secondly, we had to break a few conversational guidelines [16] for designing chat interactions to speed up prototyping (*press 1 for contacting an advisor* while chatbot design guidelines suggest that conversations with agents must be natural). For future work, we intend to fix this limitation by contextualizing the chatbot conversations for local contexts through Wizard of Oz [7]. In our pilot study, our research team answered questions which the chatbot could not answer as this study was intended to understand the feasibility of the intervention. In the next phase of the project, we plan to provide opportunities for administrators to support teachers mediated by the chatbot similar to prior work [42]. Additionally, we acknowledge that our system although intended to support the design of chatbots for emergent users in developing contexts has been piloted in a rural context. We expect more research is needed to understand the feasibility of *DIA* in other emerging economies in Latin America or the Caribbean. However, we expect our work has given a platform for future researchers to leverage our system to design chatbots in developing contexts.

We see opportunities to extend *DIA* using Crowd-AI architectures like Evorus [19] to seek support from novices to automate meaningful conversations to reduce the load on experts. In addition to using the architecture, research can learn from novices instead of crowd workers to use voting for content moderation like Sangeeth Swara [44] and content generation like Avaaj Otalo [29]. Such systems can also be used to build a crowdsourced corpus of languages with fewer data sets [34].

Furthermore, *DIA* can be used to expand research on microlearning in developing contexts by utilizing Intelligent tutors [26] on social media. The Knowledge-base from *DIA* can be used as a question bank to test users through multiple choice questions or short answers. Multimedia can be used to provide enriched content such as GIFs or short videos to create engaging conversations and questions [37]. Additionally, short and progressive incentives can help users stay motivated to complete the lesson and to cover their internet costs [40] or provide them with an additional source of income [45].

In summary, we observe from our preliminary deployment that *DIA* is feasible to mentor teachers in low resource contexts like Côte d'Ivoire . *DIA* helped us collect a database of topic-specific questions from teachers and understand the unique mobile phone usage of teachers in rural contexts. We learned that teachers use autocorrect in French through chat logs and teachers use the internet on their smartphones intermittently during the week through message delivery logs. We were also able to collect teaching-related survey responses from teachers. Although all teachers answered the first 8 questions, only 35% of teachers answered all 20 survey questions. We see opportunities for building on this research to design chatbot based interventions for the developing world.

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